Mercedes-Benz

Service

Service Manual

Diesel Engines: Multi Unit Manual

OM441, LA, OM442, A, LA, OM443, LA, OM444, A, LA

Mercedes-Benz AG
Vetrieb, Kundendients und teile
D-7000 Stuttgart 60

Foreword

This service manual contains all available information of the important assembly, adjustment and inspection jobs. Pertinent data, dimensions and tolerances, as well as special tools for various individual operations are listed within the text. The various repair and maintenance procedures outlined herein are procedures designed to be used by trained Mercedes-Benz service and repair station personnel. Supplements as such are no longer available for this Service Manual.

Mercedes-Benz of North America, Inc. recommends that repairs to, and maintenance of Mercedes-Benz automobiles be performed only by Mercedes-Benz trained personnel at authorized Mercedes-Benz repair stations.

Mercedes-Benz of North America, Inc. assumes no liability for any damage to person or property occasioned by the utilization of this publication to effect maintenance or repair work on Mercedes-Benz automobiles.

Instructions for Use of Service Manual

1. The code numbers employed for identifying the individual pages are composed as follows:

   For example: 35–1/3

   35 **Group Designation**

   35–1 **Job Number**
   –1 Job number within Group

   35–1/3 **Page Number**
   /3 Consecutive page within Job Number

   Illustrations are also carrying the Job Number, as well as a serial number.

2. All the dimensions are in millimeter (mm) unless otherwise specified, for example kilopond (kp) or liter (lits) etc.

3. Part Numbers are provided only for the identification and better differentiation of the various versions. **When ordering spare parts, be sure to use the Part Numbers provided in the Spare Parts Lists.**

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Service

Werkstatt-Handbuch Motoren OM 441-444 LA
Workshop Manual Engines OM 441-444 LA
Manuel d'atelier Moteurs OM 441-444 LA
Manual de taller Motores OM 441-444 LA

Dieser, als „Typenteil" bezeichnete Auszug, ist aus einem bestehenden, meist mehrere Motoren oder sonstige Aggregate beinhaltenden Werkstatt-Handbuch zusammengestellt. Er enthält für den genannten Motortyp die wichtigsten Daten und Einstellwerte, sowie die Beschreibung der Prüf- und Montagearbeiten. Der Gesamtinhalt ist nach den üblichen Konstruktionsgruppen aufgeteilt.
Dieser „Typenteil" unterliegt keinem Änderungsdienst. Die aufgeführten Daten, Teile-Nummern oder sonstige Angaben entsprechen in der Regel dem Stand des in der Fußnote der einzelnen Blätter angegebenen Datums.
Bei der Bestellung von Ersatzteilen und Sonderwerkzeugen ist die Teile-Nummer grundsätzlich den gültigen Ersatzteillisten bzw. dem Sonderwerkzeug-Katalog zu entnehmen.

This extract, under the heading "Component Manual" is compiled from an existing Workshop Manual containing as a rule several engines or other components. It shows the most important data and adjustment values as well as a description of test and assembly work. The total contents are divided up into the usual design groups.
This "Component Manual" is subject to no modification service. The data which has been compiled, part numbers or other details generally correspond to the data given in the footnote of each page.
When ordering spare parts and special tools the part number should always be taken from the appropriate spare parts list and the special tools catalogue.

Le présent extrait, appelé «partie types» a été relevé d'un manuel d'atelier existant qui comporte dans la plupart des cas plusieurs moteurs ou autres organes. Il contient les principales caractéristiques et valeurs de réglage du type de moteur indiqué ainsi que la description des travaux de controle et de réglage. Le contenu est subdivisé conformément aux groupes de construction habituels.
Il n'existe aucun service de modification pour cette «partie types». Les caractéristiques, numéros de pièces et autres indications sont en général ceux valables à la date marquée à l'annotation des différentes feuilles.
Pour la commande de pièces de rechange et d'outils spéciaux, les numéros de pièces doivent toujours être relevés respectivement des listes de pièces de rechange et du catalogue d'outils spéciaux en viguer.

Este extracto, designado "Manual individual", está confeccionado sobre la base de un manual de taller existente que, en la mayoria de los casos, abarca varios motores u otros grupos. El manual contiene los datos más importantes y valores de ajuste para el modelo mencionado de motor, así como la descripción de los trabajos de comprobación y montaje. El contenido íntegro está distribuido en los grupos de construcción conocidos.
Este "Manual individual" no está supeditado a servicio de modificación alguno. Los datos, números de pieza u otras indicaciones, por regla general corresponden a la situación en la fecha que se indica en la nota al pie de cada hoja.
Al cursar pedidos de repuestos o herramientas especiales, el número de pieza se deberá consultar, por principio, en las listas válidas de repuestos y en el catálogo de herramientas especiales, respectivamente.

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00 – 0002 Installation Survey

Engine type	Output in kW (HP) rpm	Version	Installed in vehicle model
441.905	160 (218) 2100	Naturally aspirated engine	650.034 652.336
441.906	150 (204) 1800	Naturally aspirated engine (low-noise vehicles)	SA[1])
441.907	150 (204) 1900	Naturally aspirated engine (Switzerland)	SA[1])
441.912	160 (218) 2100	Naturally aspirated engine	653.074
441.913	160 (218) 2100	Naturally aspirated engine	650.086
441.914	160 (218) 2100	Naturally aspirated engine	650.232/234 652.336 656.306/307
441.951	243 (330) 2100	Turbocharged engine with charge air cooling (Jumbo vehicle)	SA[1])
441.961	243 (330) 2100	Turbocharged engine with charge air cooling (Jumbo vehicle)	SA[1])
442.905	191 (260) 1900	Naturally aspirated engine	SA[1])
442.906	213 (290) 2100	Naturally aspirated engine	655.015/016/111/112 655.113/116/117/416 655.418/512/513 656/015/016/018/112 657.105/505 658.006/007/008/009 658.032/033/130/132 658.134/407/408 659.032/033/131/132 659.134
442.907	213 (290) 2100	Naturally aspirated engine	655.316/317 656.214/215/312/316 656.317 659.232/233/331/333 659.334
442.908	206 (280) 1900	Naturally aspirated engine (Switzerland)	SA[1])
442.909	206 (280) 1900	Naturally aspirated engine (Switzerland)	SA[1])
442.914	191 (260) 2100	Naturally aspirated engine	651.141/142 652.043/045/046/047 652.146/446/447/448 654.422

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[1]) SA = Optional extra

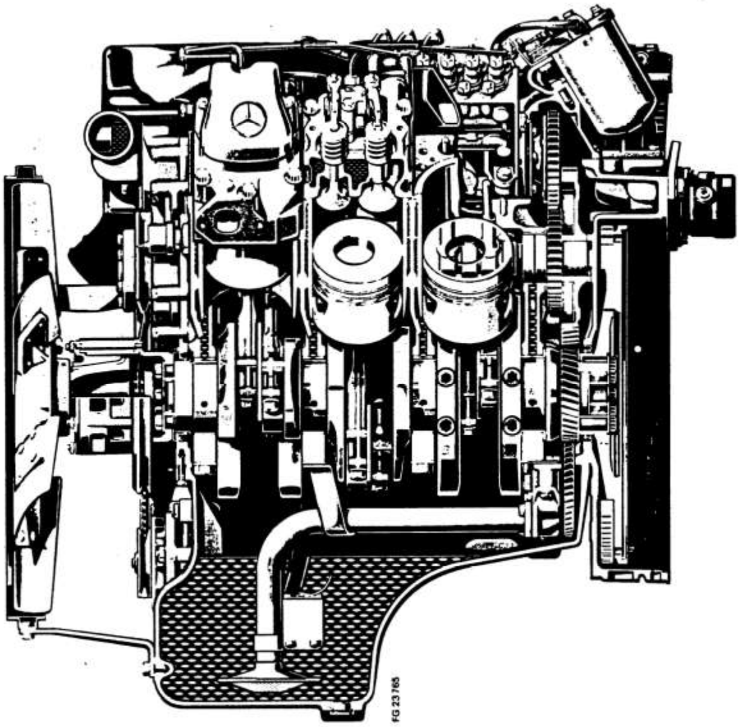
Engine type	Output in kW (HP) rpm	Version	Installed in vehicle model
442.915	213 (290) 2100	Naturally aspirated engine	625.105/135
442.916	213 (290) 2100	Naturally aspirated engine	625.101/108/138/139
442.917	213 (290) 2100	Naturally aspirated engine	659.030
442.920	191 (260) 2100	Naturally aspirated engine	650.288
442.921	191 (260) 2100	Naturally aspirated engine	653.077
442.950	260 (354) 2100	Turbocharged engine	645.026/076/122/123 645.172/173/426/476 645.522/523/573 646.025/026/027/076 646.077/121/122/123 646.172/522/523/572 646.573 648.012/013/038/063 648.111/135/413/463 655.026/076/122/123 655.172/173/426/476 655.522/523/573 656.025/026/028/076 656.078/122/123/172 658.012/013/038/063 658.135/413/463
442.951	320 (435) 2100	Turbocharged engine with charge air cooling	645.096/192/193/593 646.095/096/192/193 646.592/593 648.073/195/473 655.096/192/193/593 656.095/096 658.073/195/473
442.952	260 (354) 2100	Turbocharged engine	645.127 648.137 649.038/136/186 655.127 658.137 659.038/136/186
442.953	320 (435) 2100	Turbocharged engine with charge air cooling	649.196 659.196
442.958	260 (354) 2100	Turbocharged engine	647.110/510/560 657.110/510/560 625.121/128
442.959	260 (354) 2100	Turbocharged engine	646.322/327
442.962	260 (354) 2100	Turbocharged engine (all-wheel drive)	649.237/336/338/339

[1] SA = Optional extra

Engine type	Output in kW (HP) rpm	Version	Installed in vehicle model
442.963	260 (354) 2100	Turbocharged engine	655.026/076/122/123 655.172/173/426/476 655.522/523/573 656.025/026/028/076 656.078/122/123/172 658.012/013/038/063 658.135/413/463
442.964	260 (354) 2100	Turbocharged engine	655.127 658.137 659.038/136/186
442.965	260 (354) 2100	Turbocharged engine	657.110/510/560
442.966	260 (354) 2100	Turbocharged engine (all-wheel drive)	655.327 656.322/327 659.336/338/339
442.980	320 (435) 2100	Turbocharged engine with charge air cooling	SA¹)
442.982	320 (435) 2100	Turbocharged engine with charge air cooling	655.096/192/193/592/593 656.095/096 658.073/195/473
442.983	320 (435) 2100	Turbocharged engine with charge air cooling	659.196
442.901–400	corresponding to application	Industrial engine	for installation companies
442.901–500	corresponding to application	Industrial engine	for installation companies
443.905	269 (366) 2100	Naturally aspirated engine	655.137 656.132/133/137 656.332/337 658.142/144 659.043
443.980	401 (545) 2100	Turbocharged engine with charge air cooling	SA¹)
444.901–400	corresponding to application	Industrial engine	for installation companies
444.901–500	corresponding to application	Industrial engine	for installation companies
444.901–501	corresponding to application	Industrial engine	for installation companies

¹) SA = Optional extra

00 – 0003 Sectional Views



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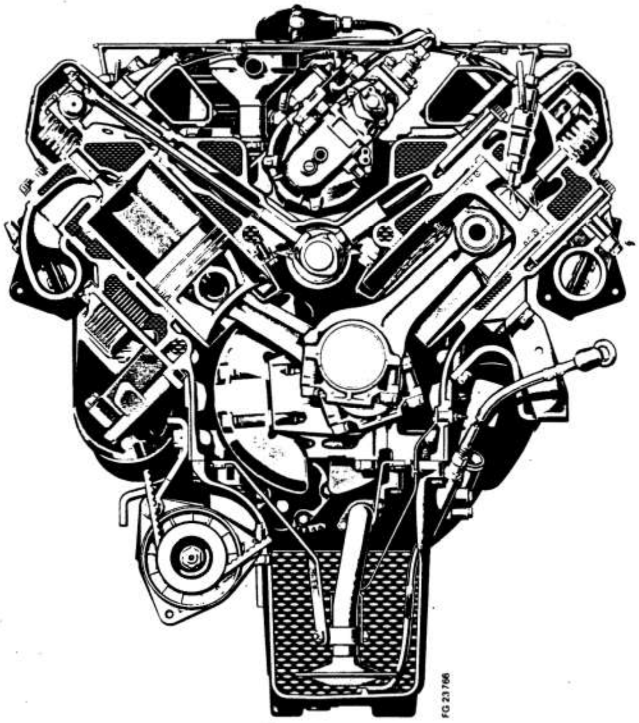

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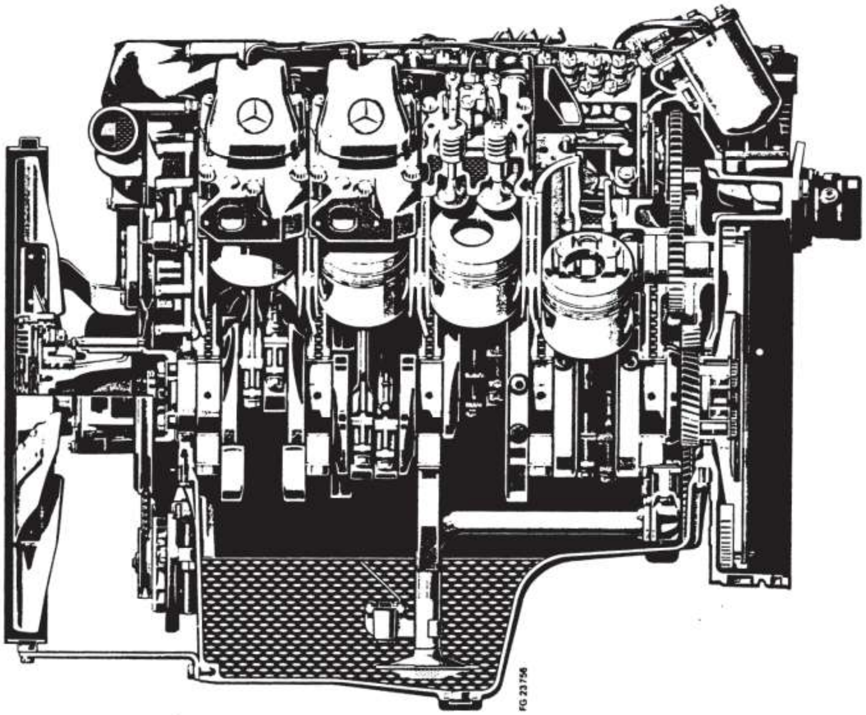
Engine OM 441



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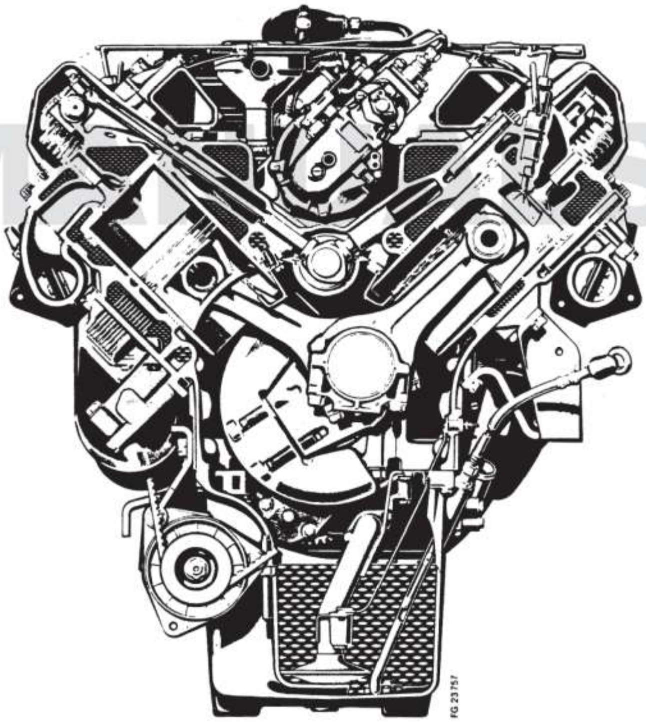

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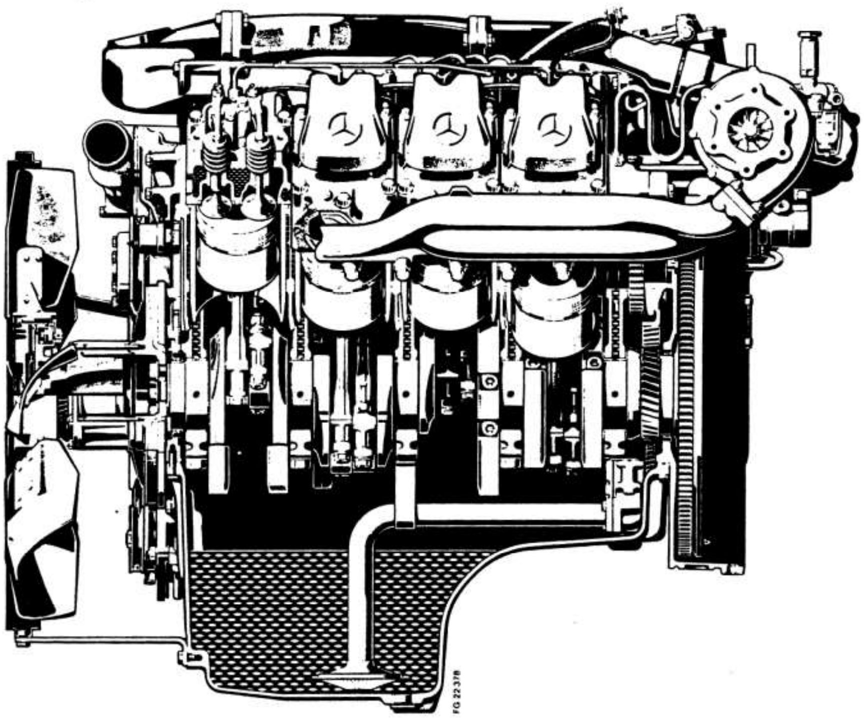
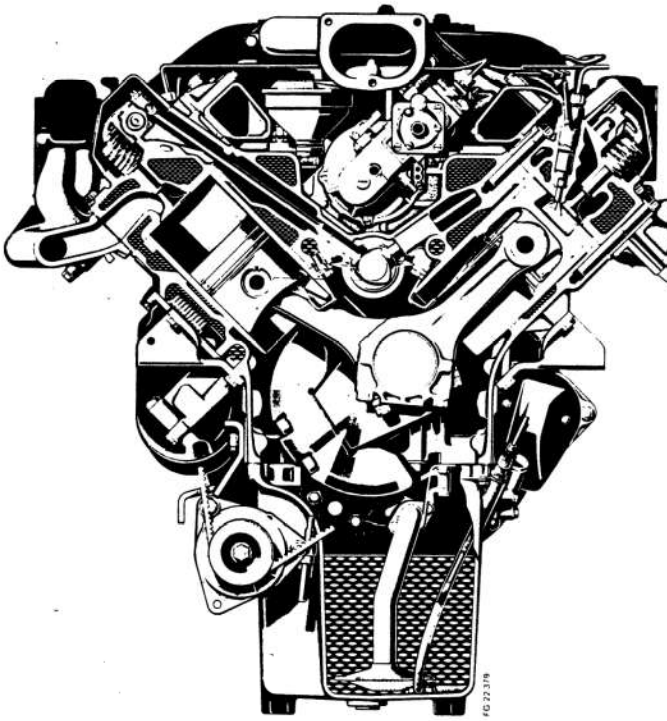
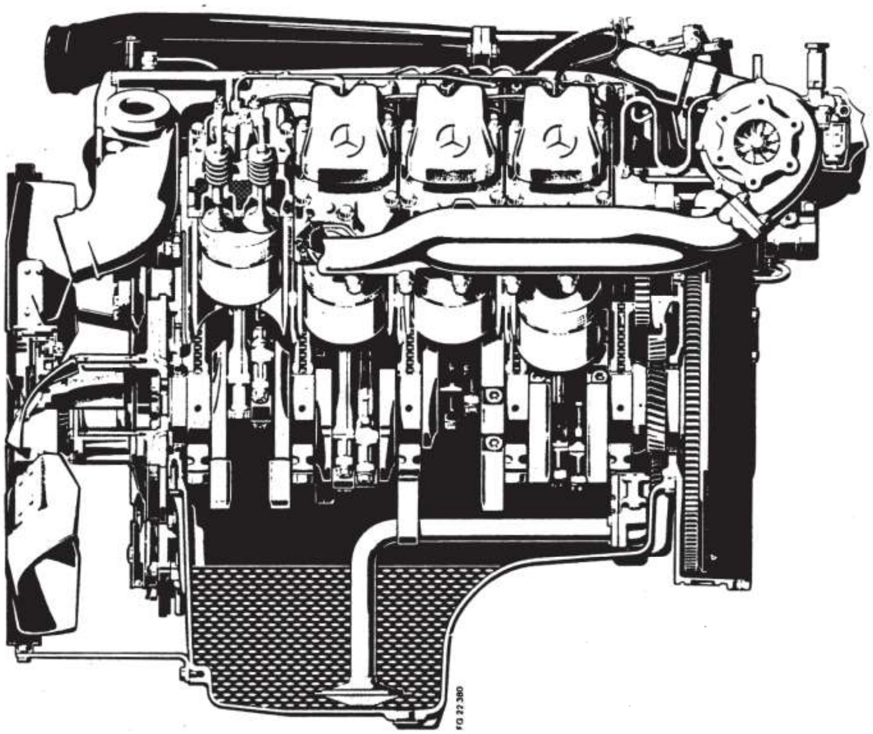
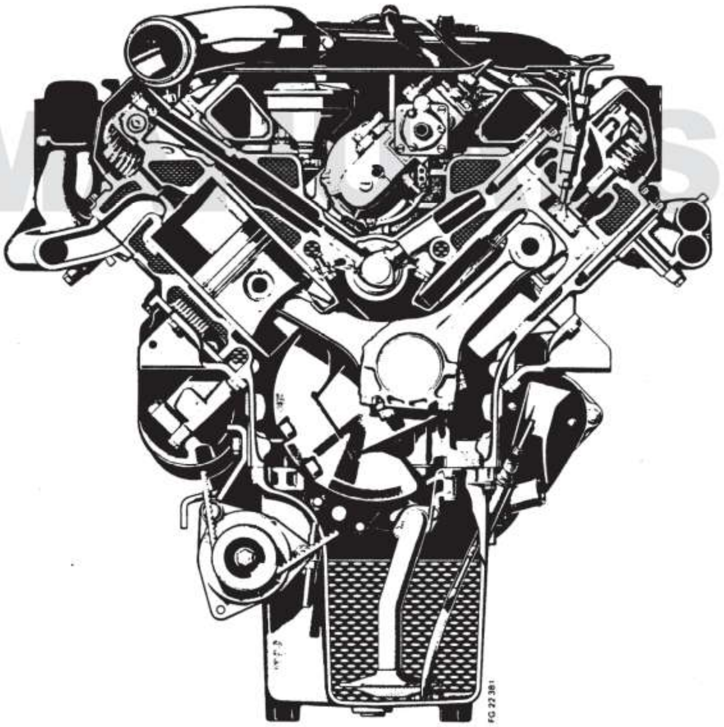
Engine OM 442





Engine OM 442 A





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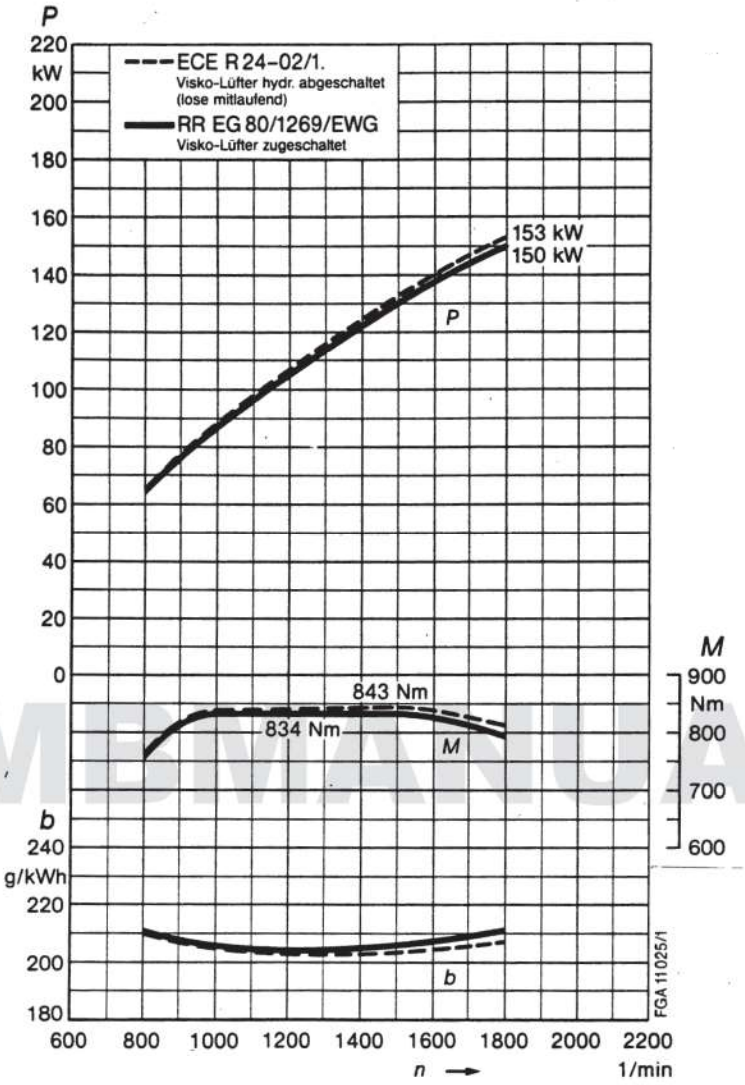
Engine OM 442 LA

00 – 0004 Special Tools

Description	Part Number
Special wrench for injection lines	000 589 07 03 00
Special wrench for pipe connections	000 589 50 03 00
Special box wrench	442 589 00 03 00
Special wrench for cylinder head bolts	403 589 02 03 00
Special wrench for injection lines	000 589 68 03 00
Pin wrench	403 589 03 07 00
Pin wrench	403 589 04 07 00
Pin wrench	403 589 05 07 00
Socket wrench insert	422 589 00 09 00
Valve adjusting wrench	321 589 00 11 00
Special wrench for nozzle holder	403 589 00 13 00
Thrust piece	312 589 00 15 00
Drift	312 589 13 15 00
Drift	352 589 08 15 00
Drift	363 589 03 15 00
Drift	403 589 00 15 00
Drift	403 589 00 15 01
Sleeve	403 589 01 15 00
Drift	403 589 03 15 00
Drift	403 589 04 15 00
Drift	403 589 05 15 00
Drift	403 589 06 15 00
Hardness tester "Scleroscope"	000 589 20 21 00
Compression tracer	001 589 78 21 00
Measuring instrument	001 589 69 21 00
Dial gauge	001 589 53 21 00
Dial gauge holder	363 590 02 21 00
Measuring plate	402 589 00 21 00

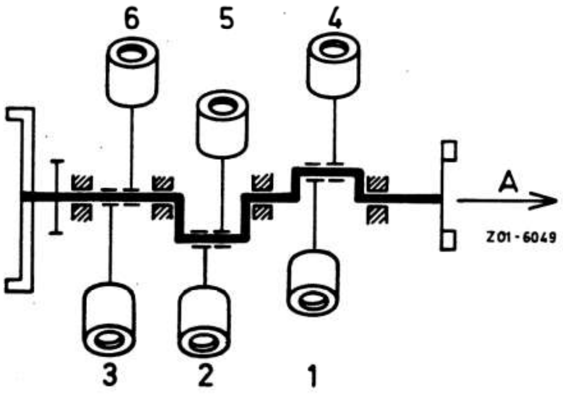
Description	Part Number
Connection piece	403 589 00 21 00
Test fixture	403 589 01 23 00
0.60 mm feeler gauge	422 589 01 23 00
0.40 mm feeler gauge	617 589 04 23 00
Hand-held gun	000 589 01 25 00
Nozzle tester	000 589 14 27 00
Heli-coil tool box M 6, M 8, M 10, M 12, M 14	000 589 03 28 00
Heli-coil tool box M 8 x 1; M 12 x 1.5; M 14 x 1.5; M 14 x 1.25	000 589 04 28 00
Heli-coil tool box M 15 x 2	000 589 05 28 00
Heli-coil tool box M 16 x 1.5	000 589 06 28 00
Heli-coil tool box M 18 x 1.5	000 589 07 28 00
Heli-coil tool box M 24 x 1.5	000 589 08 28 00
Heli-coil tool box M 26 x 1.5	000 589 09 28 00
Heli-coil tool box M 16	000 589 10 28 00
Heli-coil tool box M 30 x 1.5	000 589 11 28 00
Ring compressor	000 589 38 31 00
Mount for nozzle holder	403 589 00 31 00
Internal extractor	000 589 27 33 00
Internal extractor	000 589 28 33 00
Internal extractor for exhaust	000 589 29 33 00
Internal extractor for inlet	000 589 30 33 00
Support	000 589 34 33 00
Support	000 589 35 33 00
Puller	000 589 45 33 00
Puller	000 589 65 33 00
Extractor/Installer	403 589 00 33 00
Puller	403 589 01 33 00
Extractor/Installer	403 589 02 33 00
Piston ring pliers	000 589 37 37 00
Drift	198 589 03 39 00
Dial gauge holder	343 589 00 40 00

Description	Part Number
Feeler gauge holder	617 589 00 40 00
Reamer	000 589 12 53 00
Adjustable reamer	000 589 17 53 00
Piston ring clamp	000 589 20 61 00
Installation sleeve	403 589 00 61 00
Thrust piece	321 589 00 63 00
Supercooling box	346 589 00 63 00
Striking tool	355 589 01 63 00
Blocking fixture	403 589 01 63 00
Guide pin	403 589 02 63 00
Setting gauge for previous injection pump Setting gauge for new injection pump	403 589 04 63 00 422 589 00 63 00
Assembly fixture	403 589 05 63 00
Engine cranking device	407 589 00 63 00
Bosch nozzle cleaning unit	000 589 00 68 00
Valve seat turning tool	000 589 16 69 00
High pressure pump	422 589 00 71 00
Adapter	403 589 00 91 00



OM 441 – 150 kW

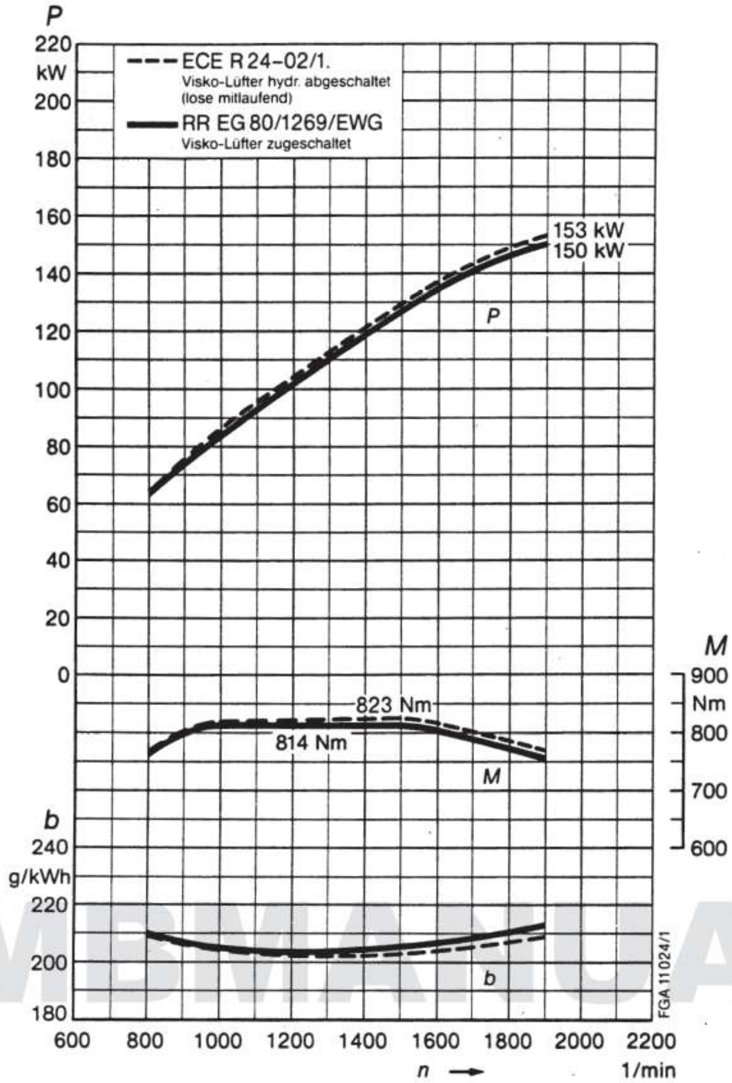
Engine model	441.906
Engine output to 80/1269/EEC	150 kW at 1800 rpm (204 HP at 1800 rpm)
Maximum torque to DIN	834 NM at 1000–1500 rpm
Nominal speed	1800 rpm
Number of cylinders	6
Bore	130 mm
Stroke	142 mm
Total displacement	11.309 cm^3



Arrangement for pistons and cylinders A = Forward direction

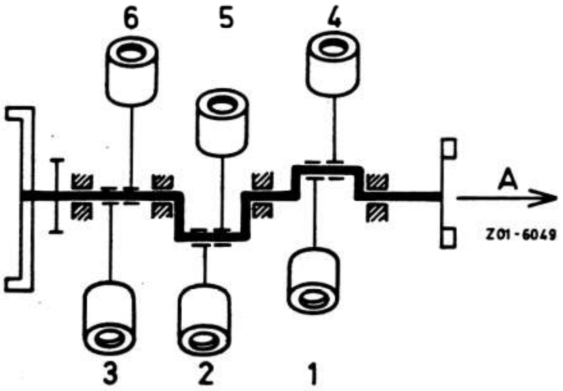
Operation	Diesel 4-stroke
Start of delivery	12° before TDC
Compression	16.9
Firing sequence	1–4–2–5–3–6
Valve overlap	5–3–6–1–4–2
Compression at approx. 120 rpm	min. 20 bar
Valve clearance inlet	0.40 mm
exhaust	0.60 mm

Injection pressure of injection nozzles	
new	175 + 10 bar
used	min. 165 bar
Engine oil capacity	
Oil pan with oil filter	max. approx. 17 l min. approx. 13 l
Minimum oil pressure at	
600 rpm	0.5 bar
1800 rpm	2.0 bar



OM 441 – 150 kW

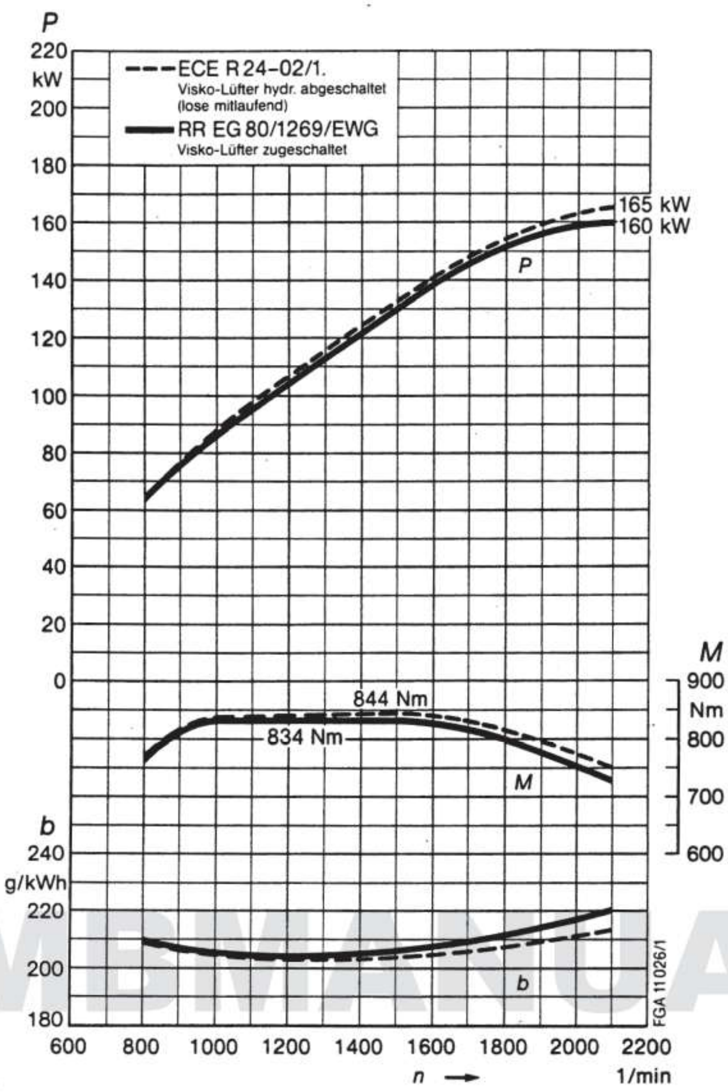
Engine model	441.907
Engine output to 80/1269/EEC	150 kW at 1900 rpm (204 HP at 1900 rpm)
Maximum torque to DIN	814 NM at 1000–1500 rpm
Nominal speed	1900 rpm
Number of cylinders	6
Bore	130 mm
Stroke	142 mm
Total displacement	11.309 cm^3



Arrangement of pistons and cylinders A = Forward direction

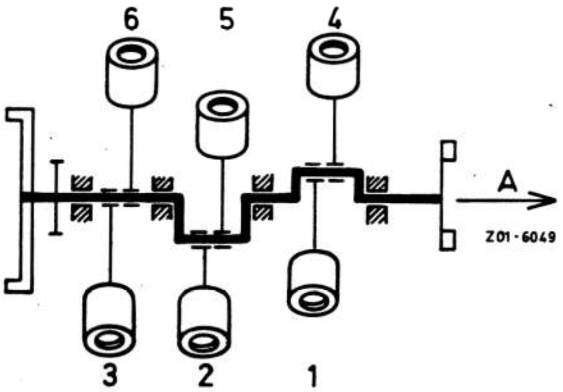
Operation	Diesel 4-stroke
Start of delivery	12° before TDC
Compression	16.9
Firing sequence	1–4–2–5–3–6
Valve overlap	5–3–6–1–4–2
Compression at approx. 120 rpm	min. 20 bar
Valve clearance inlet	0.40 mm
exhaust	0.60 mm

Injection pressure of injection nozzles	
new	175 + 10 bar
used	min. 165 bar
Engine oil capacity	
Oil pan with oil filter	max. approx. 17 l min. approx. 13 l
Minimum oil pressure at	
600 rpm	0.5 bar
1800 rpm	2.0 bar



OM 441 – 160 kW

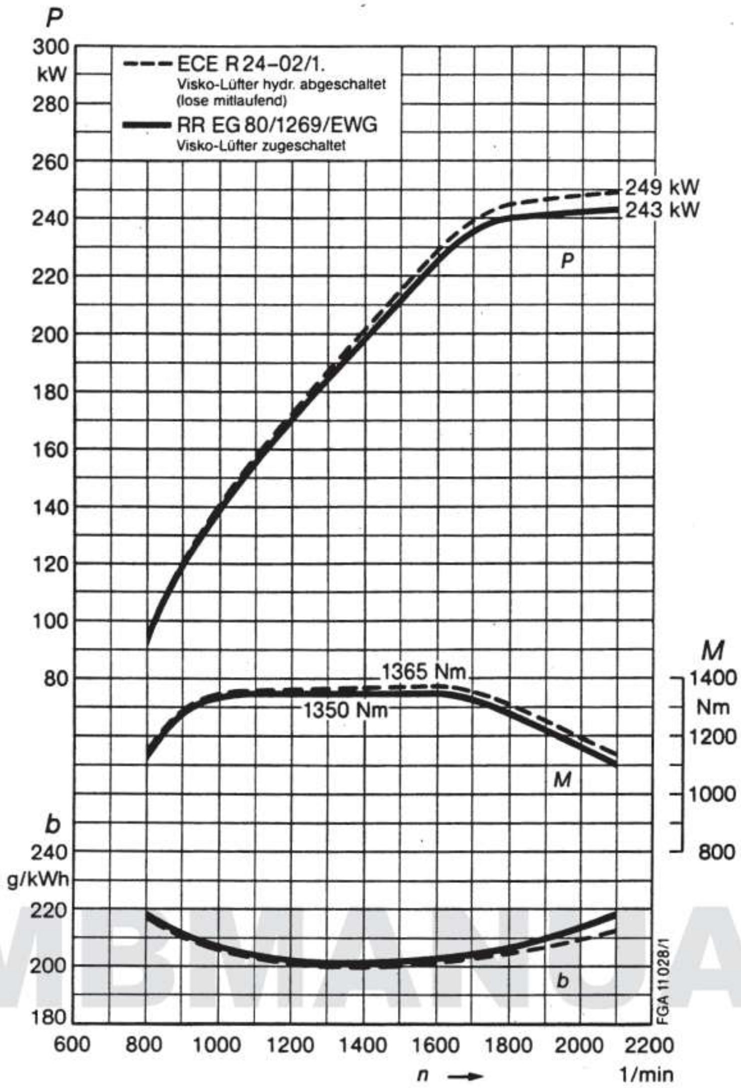
Engine model	441.905 441.912 441.913 441.914
Engine output to 80/1269/EEC	160 kW at 2100 rpm (218 HP at 2100 rpm)
Maximum torque to DIN	834 NM at 1000–1500 rpm
Nominal speed	2100 rpm
Number of cylinders	6
Bore	130 mm
Stroke	142 mm
Total displacement	11.309 cm^3



Arrangement of pistons and cylinders A = Forward direction

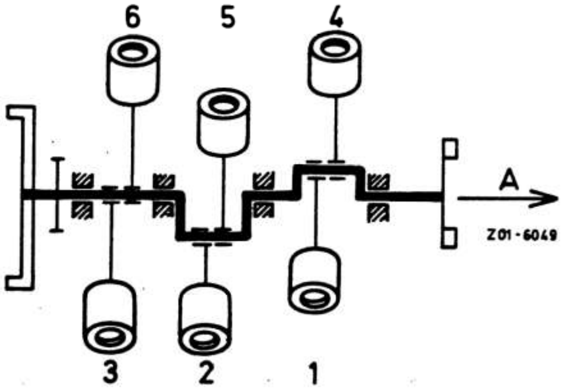
Operation	Diesel 4-stroke
Start of delivery	14° before TDC
Compression	16.9
Firing sequence	1–4–2–5–3–6
Valve overlap	5-3-6–1–4–2
Compression at approx. 120 rpm	min. 20 bar
Valve clearance inlet	0.40 mm
exhaust	0.60 mm

Injection pressure of injection nozzles	
new	175 + 10 bar
used	min. 165 bar
Engine oil capacity	
Oil pan with oil filter	max. approx. 17 l min. approx. 13 l
Minimum oil pressure at	
600 rpm	0.5 bar
1800 rpm	2.0 bar



OM 441 LA – 243 kW

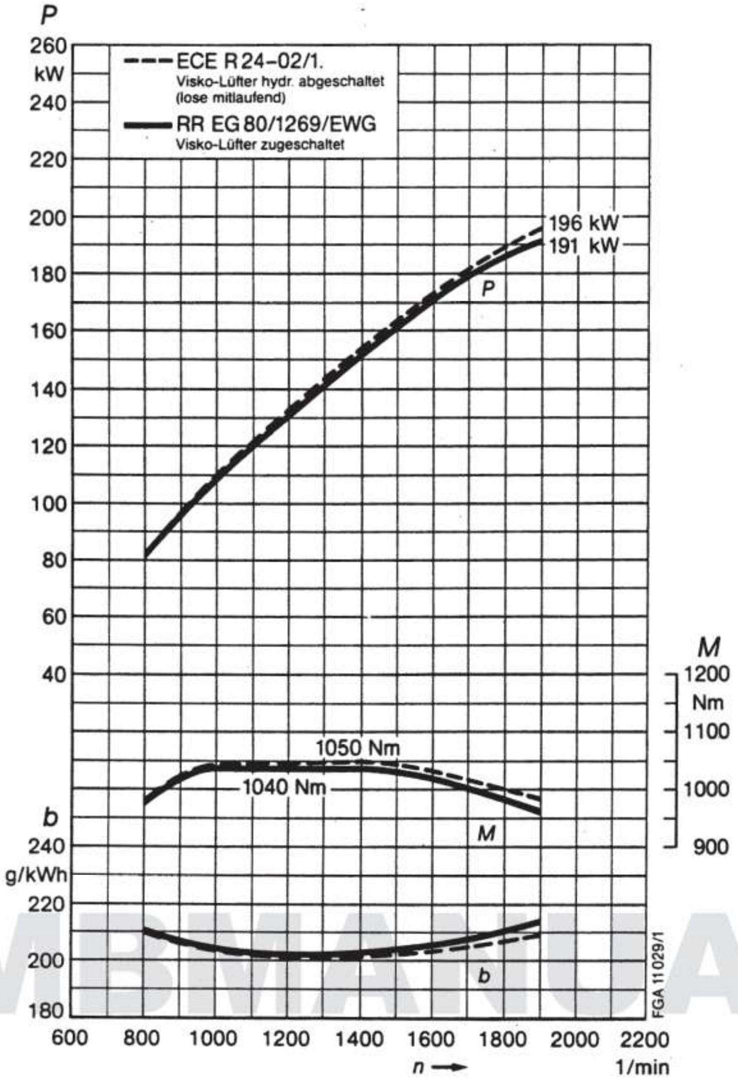
Engine model	441.951 961
Engine output to 80/1269/EEC	243 kw at 2100 rpm (330 HP at 2100 rpm)
Maximum torque to DIN	1350 Nm at 1100–1600 rpm
Nominal speed	2100 rpm
Number of cylinders	6
Bore	128 mm
Stroke	142 mm
Total displacement	10.964 cm^3



Arrangement of pistons and cylinders A = Forward direction

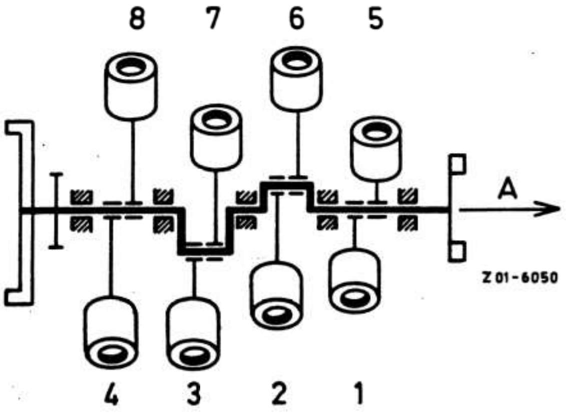
Operation	Diesel 4-stroke
Start of delivery	10° before TDC
Compression	16.25
Firing sequence	1–4–2–5–3–6
Valve overlap	5–3–6–1–4–2
Compression at approx. 120 rpm	min. 20 bar
Valve clearance inlet	0.40 mm
exhaust	0.60 mm

Injection pressure of injection nozzles	
new	200 + 8 bar
used	min. 175 bar
Engine oil capacity	
Oil pan with oil filter	min. approx. 21.5 l
	min. approx. 15.5 l
Minimum oil pressure at	
600 rpm	0.5 bar
1800 rpm	2.0 bar



OM 442' – 191 kW

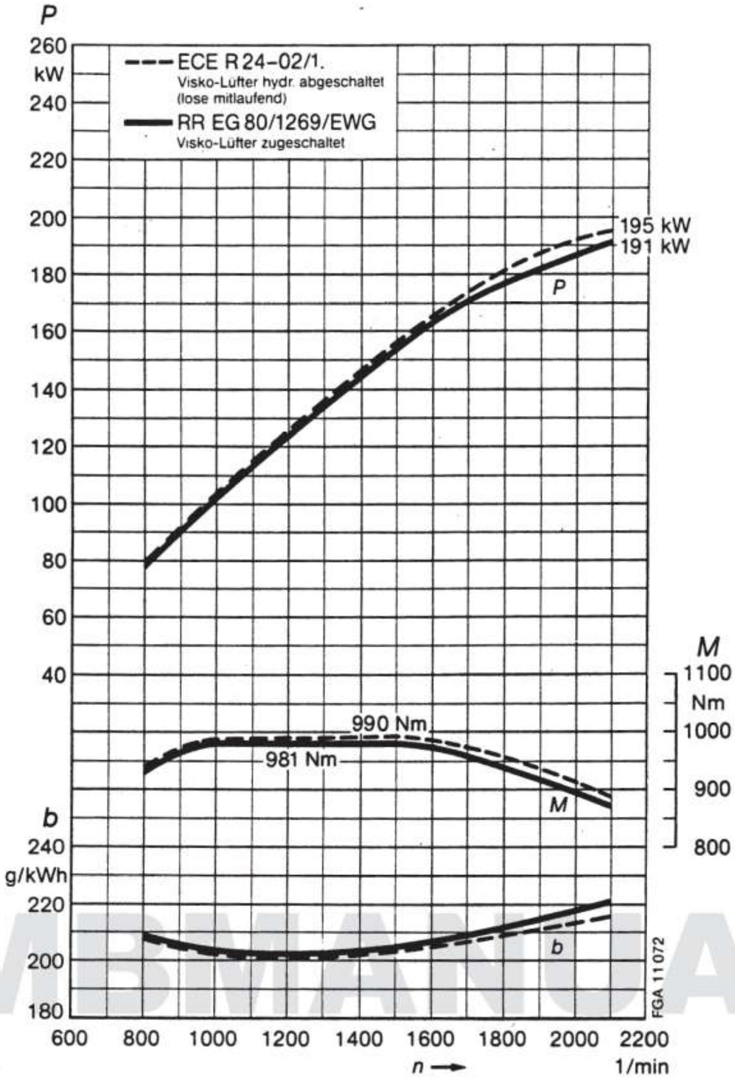
Engine model	442.905
Engine output to 80/1269/EEC	191 kW at 1900 rpm (260 HP at 1900 rpm)
Maximum torque to DIN	1040 Nm at 1000–1400 rpm
Nominal speed	1900 rpm
Number of cylinders	8
Bore	130 mm
Stroke	142 mm
Total displacement	15.078 cm^3



Arrangement of pistons and cylinders   A = Forward direction

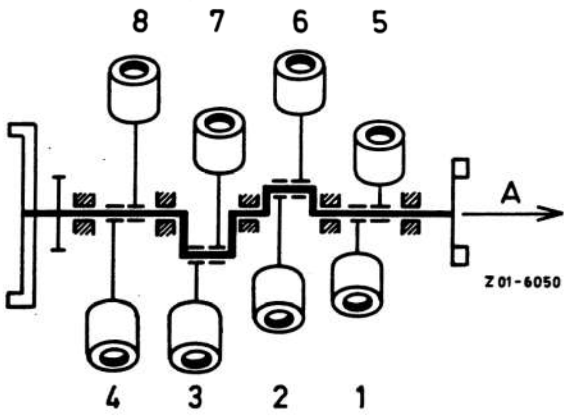
Operation	Diesel 4-stroke
Start of delivery	12° before TDC
Compression	16.9
Firing sequence	1–5–7–2–6–3–4–8
Valve overlap	6–3–4–8–1–5–7–2
Compression at approx. 120 rpm	min. 20 bar
Valve clearance inlet	0.40 mm
exhaust	0.60 mm

Injection pressure of injection nozzles	
new	175 + 10 bar
used	min. 165 bar
Engine oil capacity	
Oil pan with oil filter	max. approx. 23 l
	min. approx. 16.5 l
Minimum oil pressure at	
600 rpm	0.5 bar
1800 rpm	2.0 bar



OM 441 – 191 kW

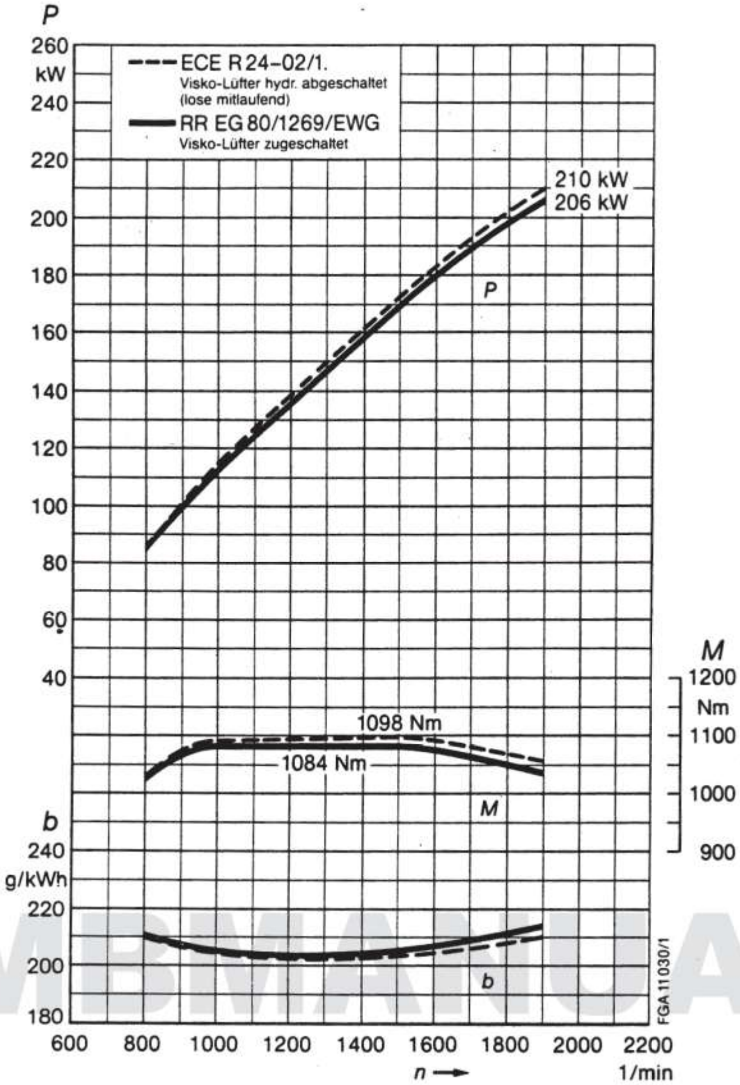
Engine model	442.914 920 921
Engine output to 80/1269/EEC	191 kW at 2100 rpm (260 HP at 2100 rpm)
Maximum torque to DIN	981 Nm at 1000–1500 rpm
Nominal speed	2100 rpm
Number of cylinders	8
Bore	130 mm
Stroke	142 mm
Total displacement	15.078 cm^3



Arrangement of pistons and cylinders A = Forward direction

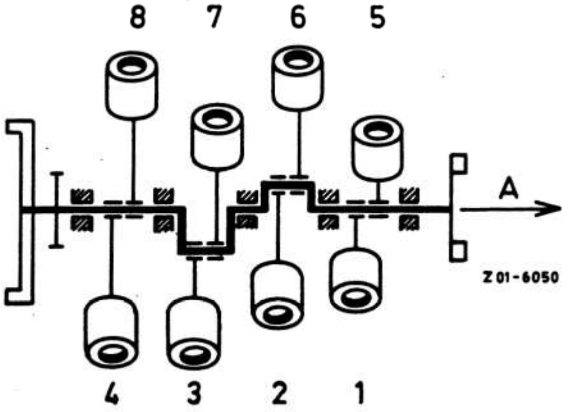
Operation	Diesel 4-stroke
Start of delivery	14° before TDC
Compression	16.9
Firing sequence	1–5–7–2–6–3–4–8
Valve overlap	6–3–4–8–1–5–7–2
Compression at approx. 120 rpm	min. 20 bar
Valve clearance inlet	0.40 mm
exhaust	0.60 mm

Injection pressure of injection nozzles	
new	175 + 10 bar
used	min. 165 bar
Engine oil capacity	
Oil pan with oil filter	max. approx. 23 l min. approx. 16.5 l
Minimum oil pressure at	
600 rpm	0.5 bar
1800 rpm	2.0 bar



OM 442 – 206 kW

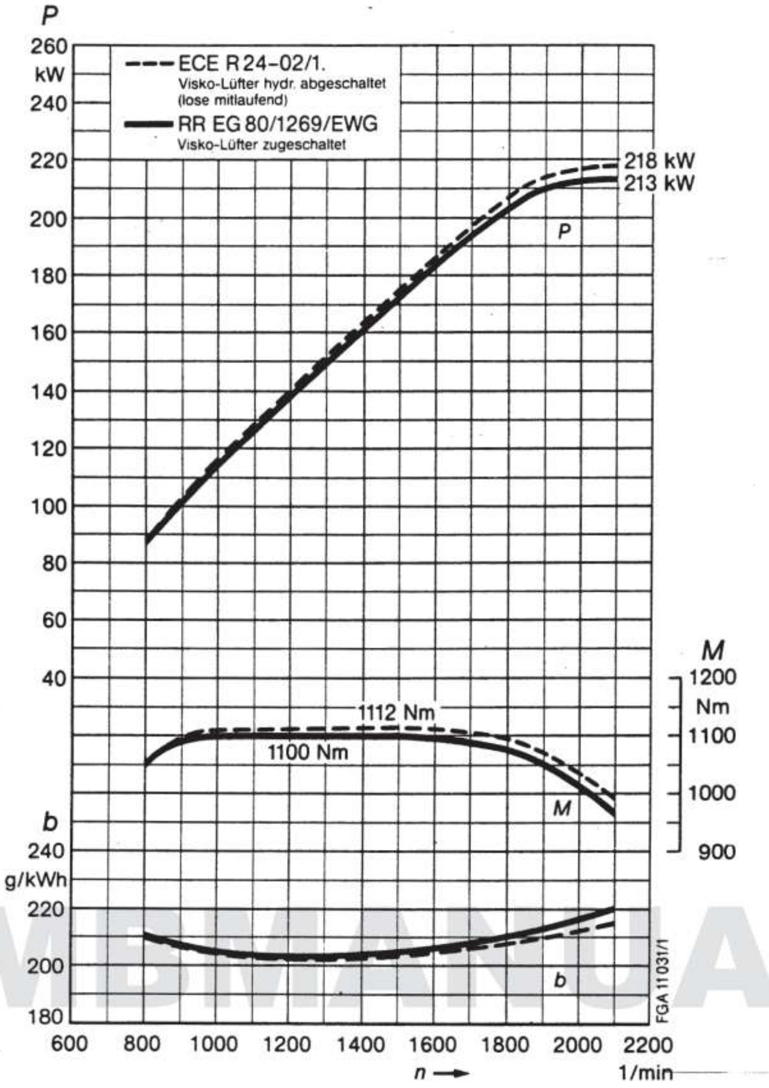
Engine model	442.908 909
Engine output to 80/1269/EEC	206 kW at 1900 rpm (280 HP at 1900 rpm)
Maximum torque to DIN	1084 Nm at 1000–1500 rpm
Nominal speed	1900 rpm
Number of cylinders	8
Bore	130 mm
Stroke	142 mm
Total displacement	15.078 cm^3



Arrangement of pistons and cylinders A = forward direction

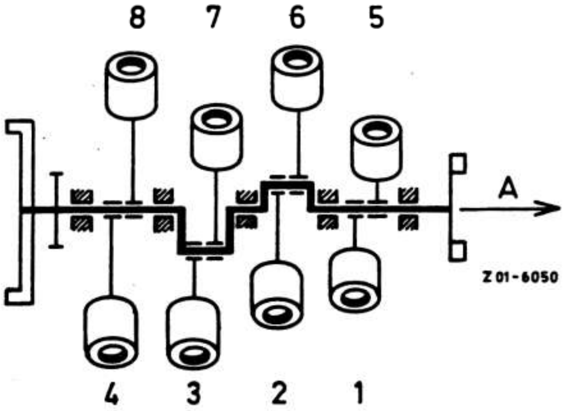
Operation	Diesel 4-stroke
Start of delivery	12° before TDC
Compression	16.9
Firing sequence	1–5–7–2–6–3–4–8
Valve overlap	6–3–4–8–1–5–7–2
Compression at approx. 120 rpm	min. 20 bar
Valve clearance inlet	0.40 mm
exhaust	0.60 mm

Injection pressure of injection nozzles	
new	175 + 10 bar
used	min. 165 bar
Engine oil capacity	
Oil pan with oil filter	max. approx. 23 l min. approx. 16.5 l
Minimum oil pressure at	
600 rpm	0.5 bar
1800 rpm	2.0 bar



OM 442 – 213 kW

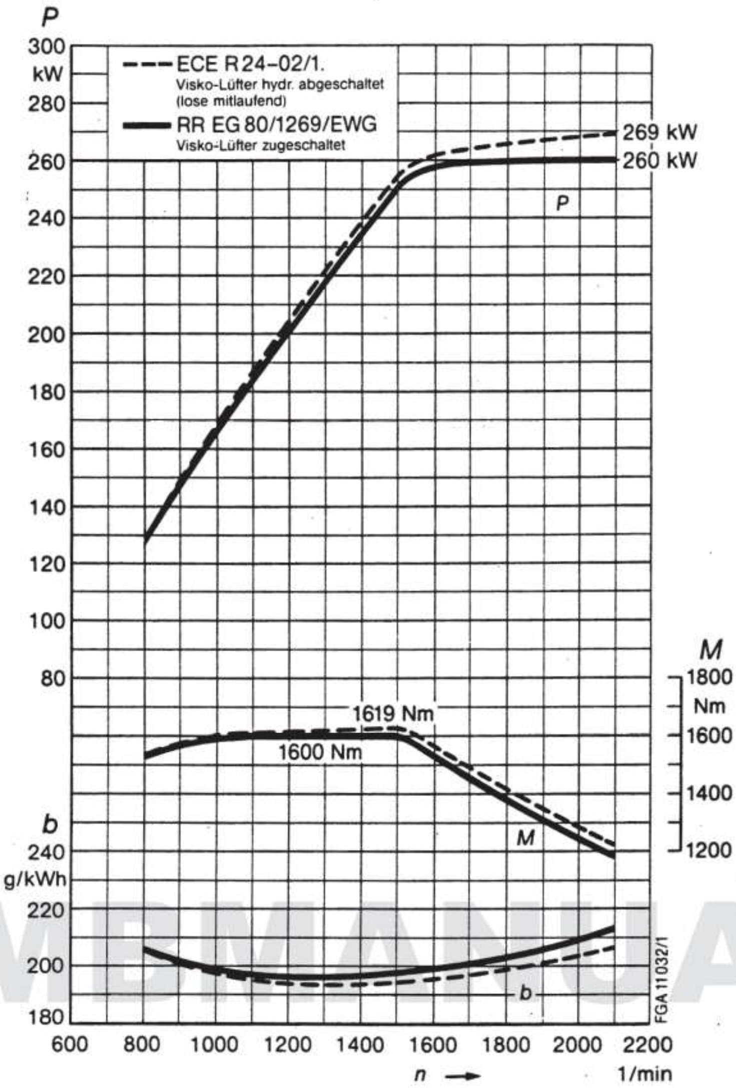
Engine model	442.906 907 915 916 917
Engine output to 80/1269/EEC	213 kW at 2100 rpm (290 HP at 2100 rpm)
Maximum torque to DIN	1100 Nm at 1000–1500 rpm
Nominal speed	2100 rpm
Number of cylinders	8
Bore	130 mm
Stroke	142 mm
Total displacement	15.078 cm³



Arrangement of pistons and cylinders A = Forward direction

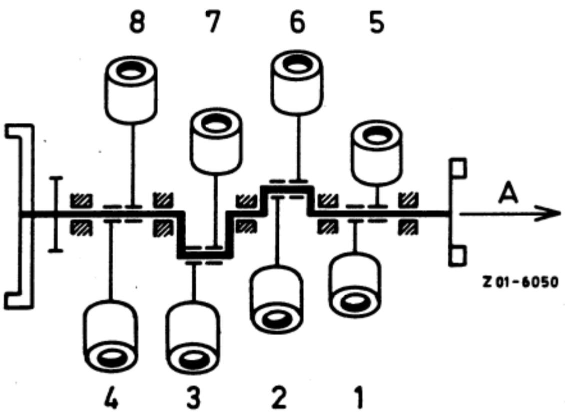
Operation	Diesel 4-stroke
Start of delivery	14° before TDC
Compression	16.9
Firing sequence	1–5–7–2–6–3–4–8
Valve overlap	6–3–4–8–1–5–7–2
Compression at approx. 120 rpm	min. 20 bar
Valve clearance inlet	0.40 bar
exhaust	0.60 mm

Injection pressure of injection nozzles	
new	175 + 10 bar
used	min. 165 bar
Engine oil capacity	
Oil pan with oil filter	max. approx. 23 l min. approx. 16,5 l
Minimum oil pressure at	
600 rpm	0.5 bar
1800 rpm	2.0 bar



OM 442 A – 260 kW

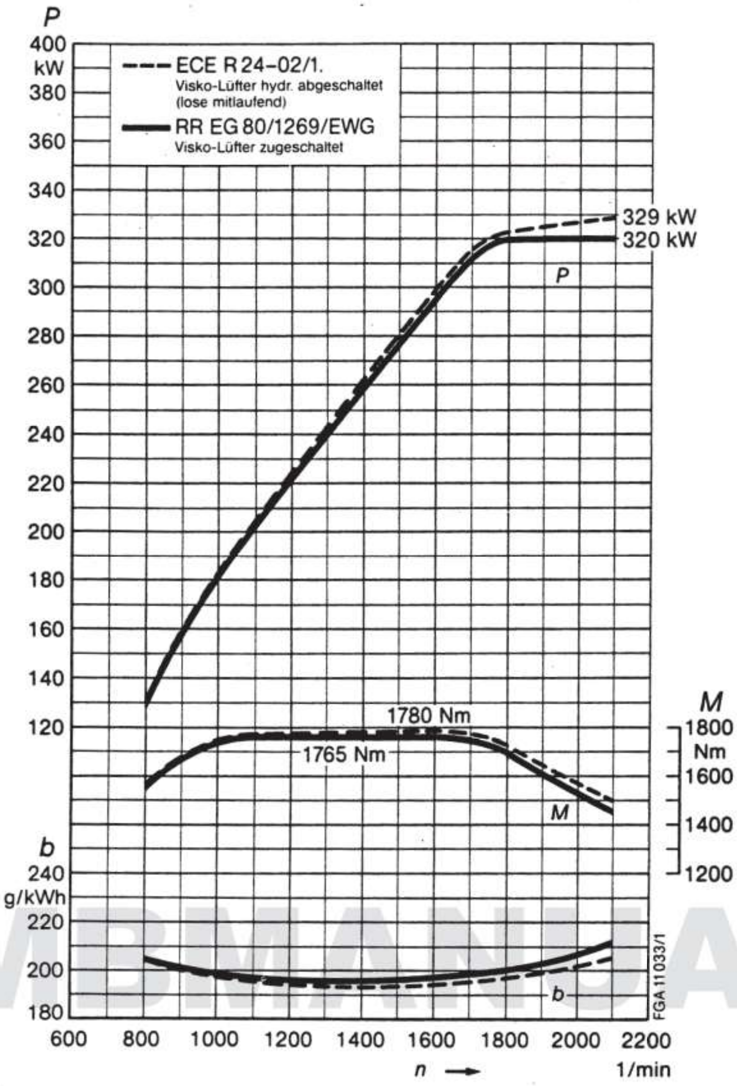
Engine model	442.950 952 958 959 962 963 964 965 966
Engine output to 80/1269/EEC	260 kW at 2100 rpm (354 HP at 2100 rpm)
Maximum torque to DIN	1600 Nm at 1100–1500 rpm
Nominal speed	2100 rpm
Number of cylinders	8
Bore	128 mm
Stroke	142 mm
Total displacement	14.618 cm^3



Arrangement of pistons and cylinders A = Forward direction

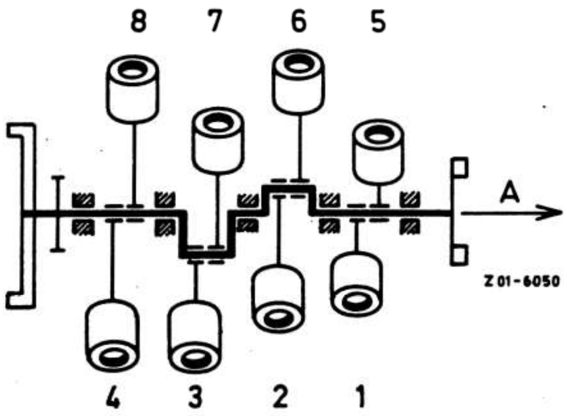
Operation	Diesel 4-stroke
Start of delivery	14° before TDC
Compression	16.25
Firing sequence	1–5–7–2–6–3–4–8
Valve overlap	6–3–4–8–1–5–7–2
Compression at approx. 120 rpm	min. 20 bar
Valve clearance inlet	0.40 mm
exhaust	0.60 mm

Injection pressure of injection nozzles	
new	200 + 8 bar
used	min. 175 bar
Engine oil capacity	
Oil pan with oil filter	max. approx. 27 l min. approx. 19,5 l
Minimum oil pressure at	
600 rpm	0.5 bar
1800 rpm	2.0 bar



OM 442 LA – 320 kW

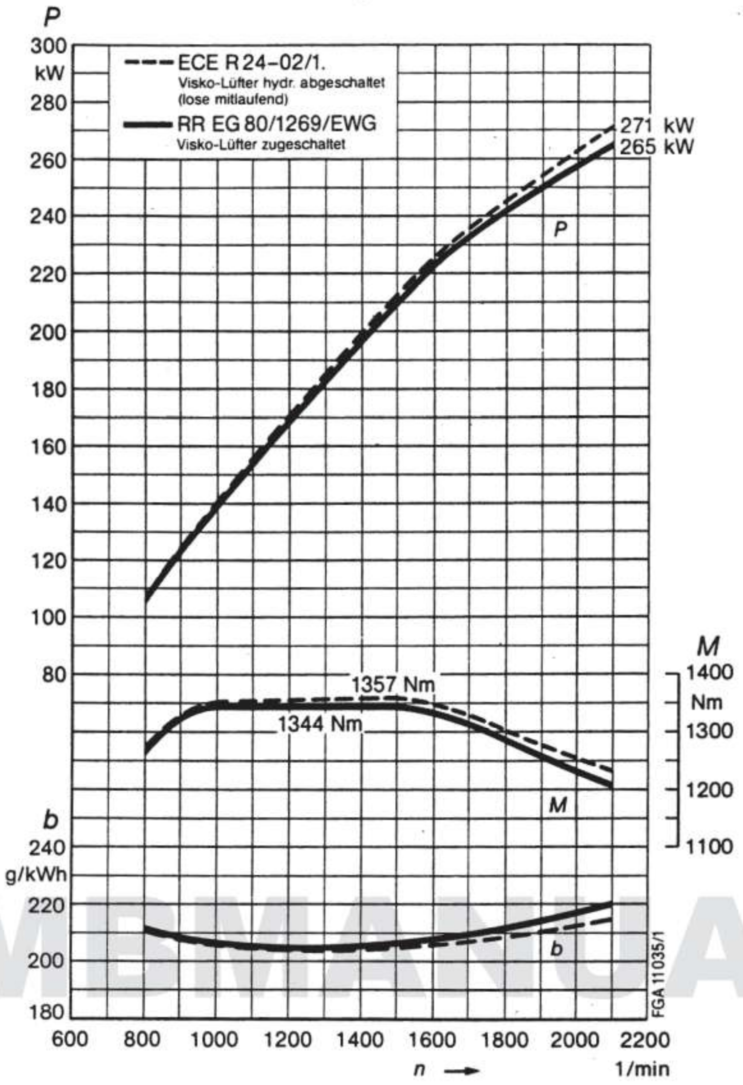
Engine model	442.951 953 980 982 983
Engine output to 80/1269/EEC	320 kW at 2100 rpm (435 HP at 2100 rpm)
Maximum torque to DIN	1765 Nm at 1100–1600 rpm
Nominal speed	2100 rpm
Number of cylinders	8
Bore	128 mm
Stroke	142 mm
Total displacement	14.618 cm^3



Arrangement of pistons and cylinders A = Forward direction

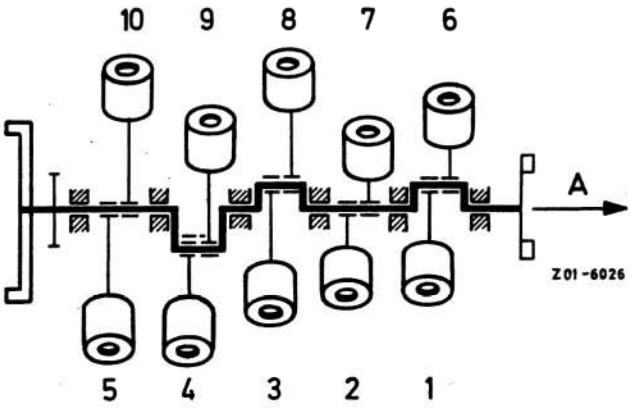
Operation	Diesel 4-stroke
Start of delivery	14° before TDC
Compression	16.25
Firing sequence	1–5–7–2–6–3–4–8
Valve overlap	6–3–4–8–1–5–7–2
Compression at approx. 120 rpm	min. 20 bar
Valve clearance inlet	0.40 mm
exhaust	0.60 mm

Injection pressure of injection nozzles	
new	200 + 8 bar
used	min. 175 bar
Engine oil capacity	
Oil pan with oil filter	max. approx. 27 l min. approx. 19,5 l
Minimum oil pressure at	
600 rpm	0.5 bar
1800 rpm	2.0 bar



OM 443 – 265 kW

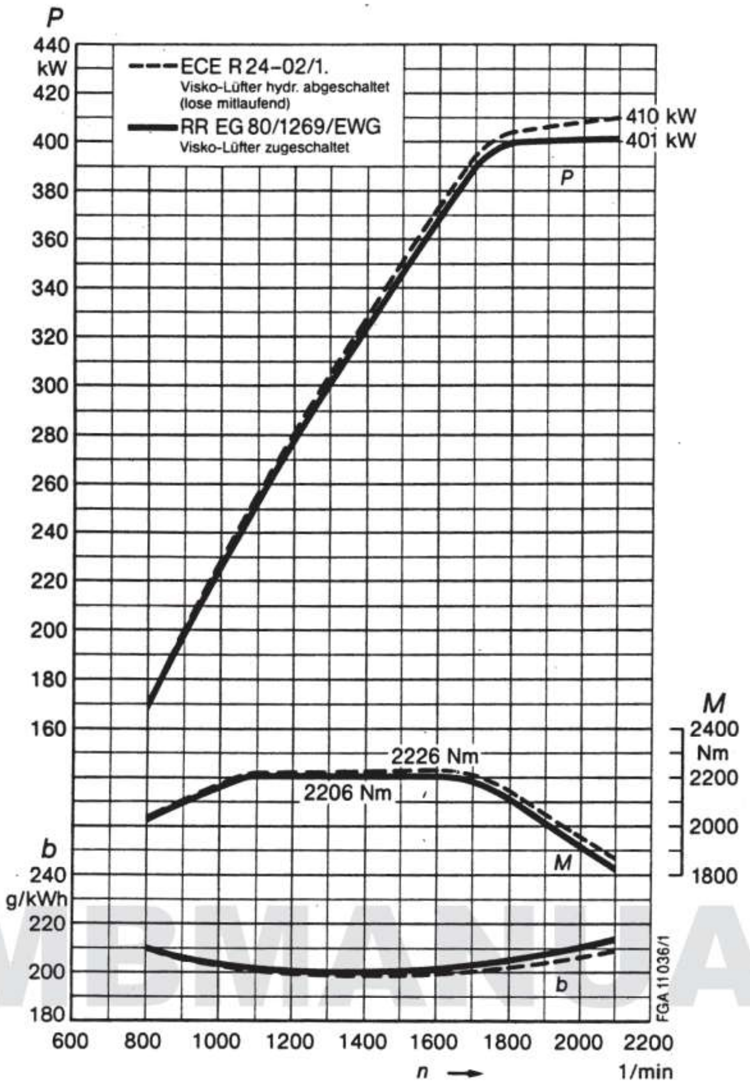
Engine model	443.905
Engine output to 80/1269/EEC	265 kW at 2100 rpm (360 HP at 2100 rpm)
Maximum torque to DIN	1344 Nm at 1000–1500 rpm
Nominal speed	2100 rpm
Number of cylinders	10
Bore	130 mm
Stroke	142 mm
Total displacement	18.848 cm^3



Arrangement of pistons and cylinders A = Forward direction

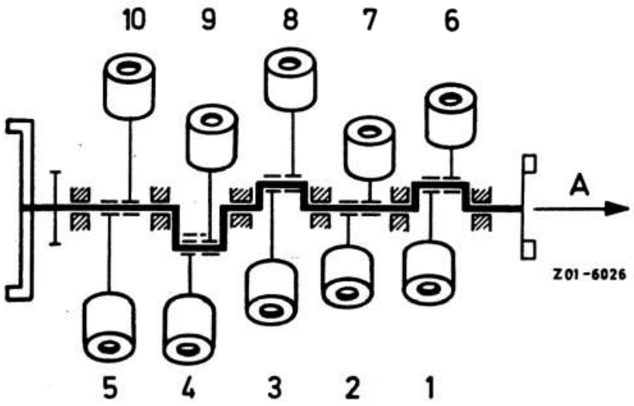
Operation	Diesel 4-stroke
Start of delivery	14° before TDC
Compression	16.9
Firing sequence	1–6–5–10–2–7–3–8–4–9
Valve overlap	7–3–8–4–9–1–6–5–10–2
Compression at approx. 120 rpm	min. 20 bar
Valve clearance inlet	0.40 mm
exhaust	0.60 mm

Injection pressure of injection nozzles	
new	175 + 10 bar
used	min. 165 bar
Engine oil capacity	
Oil pan with oil filter	max. approx. 28.5 l min. approx. 20.5 l
Minimum oil pressure at	
600 rpm	0.5 bar
1800 rpm	2.0 bar



OM 443 LA – 401 kW

Engine model	443.980
Engine output to 80/1269/EEC	401 kW at 2100 rpm (545 HP at 2100 rpm)
Maximum torque to DIN	2206 Nm at 1100–1600 rpm
Nominal speed	2100 rpm
Number of cylinders	10
Bore	128 mm
Stroke	142 mm
Total displacement	18.273 cm^3



Arrangement of pistons and cylinders A = Forward direction

Operation	Diesel 4-stroke
Start of delivery	14° before TDC
Compression	16.25
Firing sequence	1–6–5–10–2–7–3–8–4–9
Valve overlap	7–3–8–4–9–1–6–5–10–2
Compression at approx. 120 rpm	min. 20 bar
Valve clearance inlet	0.40 mm
exhaust	0.60 mm

Injection pressure of injection nozzles	
new	200 + 8 bar
used	min. 175 bar
Engine oil capacity	
Oil pan with oil filter	max. approx. 35.5 l min. approx. 26.5 l
Minimum oil pressure at	
600 rpm	0.5 bar
1800 rpm	2.0 bar

80/1269/EEC

Max. vehicle output ————————

The power outputs are made available at the flywheel of the engine. The power requirements of the standard fan are already taken into account.

DIN 6271

Max. blocked
ISO effective output **IFN** — – — – —
(substitutes output B DIN 6270)

ISO standard output
ICXN —— —— ——
can be exceeded by 10%
(substitutes continuous output A DIN 6270)

Deviating from the Standard DIN 6271, the power requirements of a fan are not taken into consideration in the outputs IFN and ICXN due to the wide variety of cooling systems.

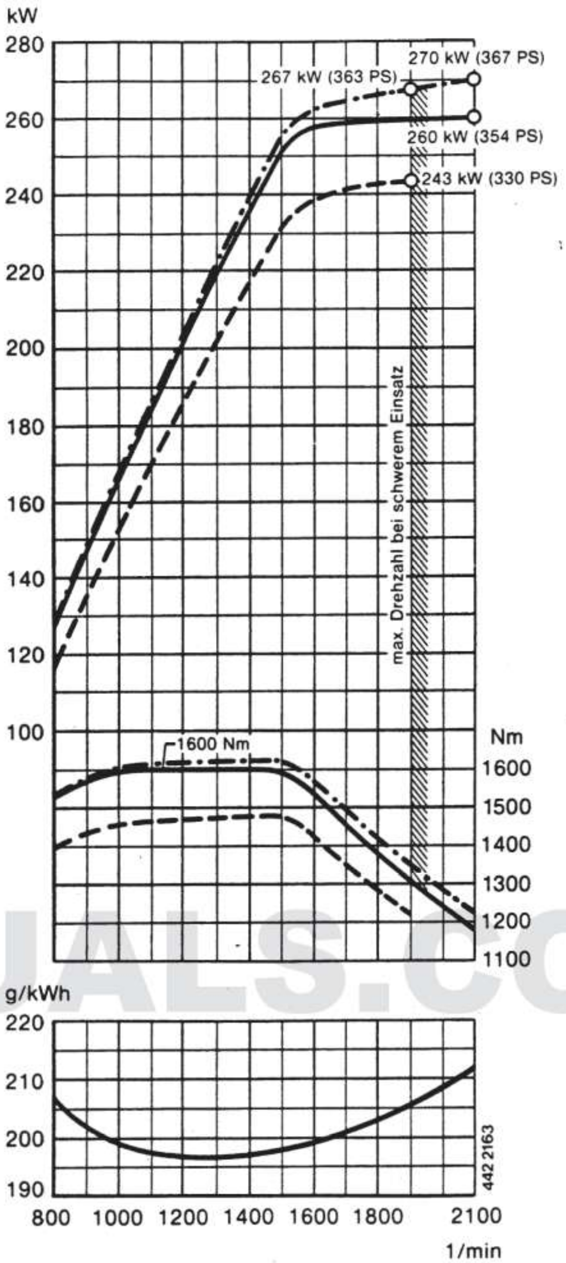
The blocked ISO effective output **IFN** cannot be exceeded, it is permissible for the duration of 1 hour continuously or interrupted within a period of 6 hours.

The ISO standard output **ICXN** is a continuous output and can be exceeded by 10%. The excess output is blocked and is permissible continuously for the duration of 1 hour or interrupted within a period of 12 hours.

The output ratings and the specific fuel consumption refer to a diesel fuel with a reference density p15 = 0.84 g/cm³ and a temperature at inlet in the injection pump fo 35° C.

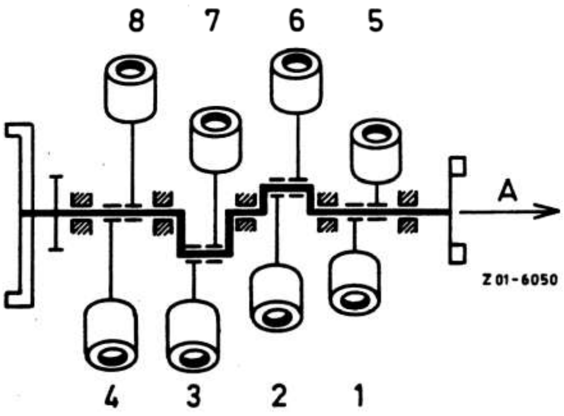
In particular cases, the output ratings depend upon the application, while taking all operating conditions into account.

Continuous operating engine speeds below 1500 rpm on request.



OM 442 A Industrial engine

Engine model	442.901–400
Engine output to 80/1269/EEC	271 kW (368 HP)
Maximum torque	1600 Nm
Nominal speed	2100 rpm
Number of cylinders	8
Bore	128 mm
Stroke	142 mm
Total displacement	14.618 cm³



Arrangement of pistons and cylinders A = Fan end

Operation	Diesel 4-stroke
Start of delivery	14° before TDC
Compression	16.25
Firing sequence	1–5–7–2–6–3–4–8
Valve overlap	6–3–4–8–1–5–7–2
Compression at approx. 120 rpm	min. 20 bar
Valve clearance inlet	0.40 mm
exhaust	0.60 mm

Injection pressure of injection nozzles	
new	200 + 8 bar
used	min. 175 bar
Engine oil capacity	
Oil pan with oil filter	max. approx. 27 l min. approx. 19.5 l
Minimum oil pressure at	
Max. engine speed	2.5 bar
Idle speed	0.5 bar

80/1269/EEC

Max. vehicle output ————

The power outputs are made available at the flywheel of the engine. The power requirements of the standard fan are already taken into account.

DIN 6271

Max. blocked
ISO effective output **IFN** — - — - —
(substitutes output B DIN 6270)

ISO standard output
ICXN — — —
can be exceeded by 10%
(substitutes continuous output A DIN 6270)

Deviating from the Standard DIN 6271, the power requirements of a fan are not taken into consideration in the outputs IFN and ICXN due to the wide variety of cooling systems.

The blocked ISO effective output **IFN** cannot be exceeded, it is permissible for the duration of 1 hour continuously or interrupted within a period of 6 hours.

The ISO standard output **ICXN** is a continuous output and can be exceeded by 10%. The excess output is blocked and is permissible continuously for the duration of 1 hour or interrupted within a period of 12 hours.

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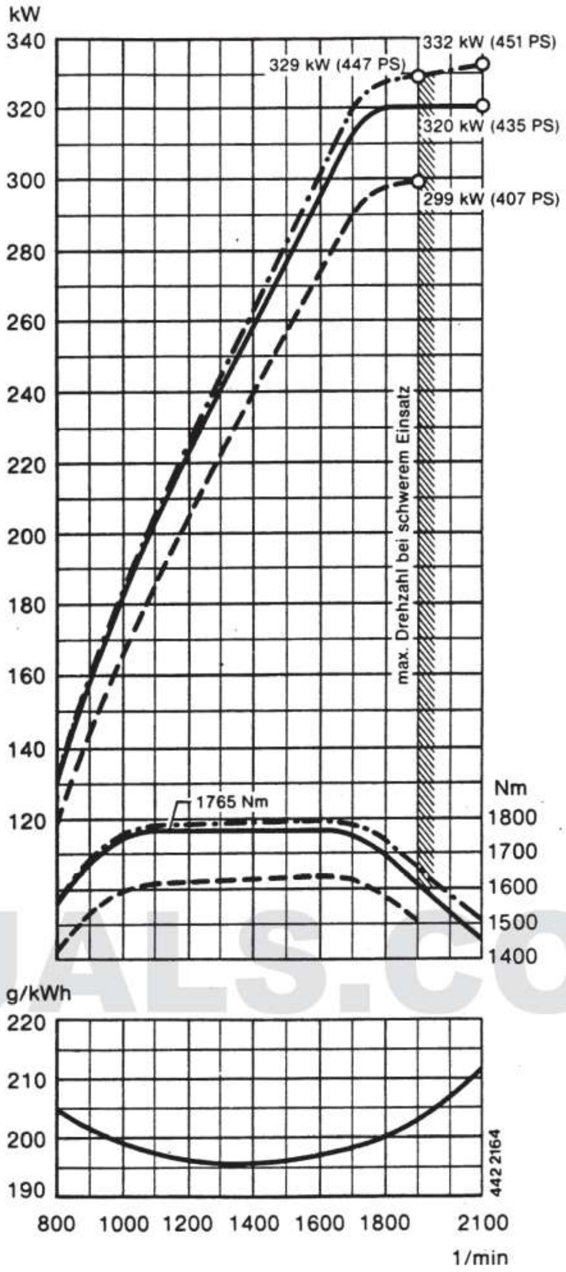
The output ratings and the specific fuel consumption refer to a diesel fuel with a reference density p15 = 0.84 g/cm^3 and a temperature at inlet in the injection pump of 35° C.

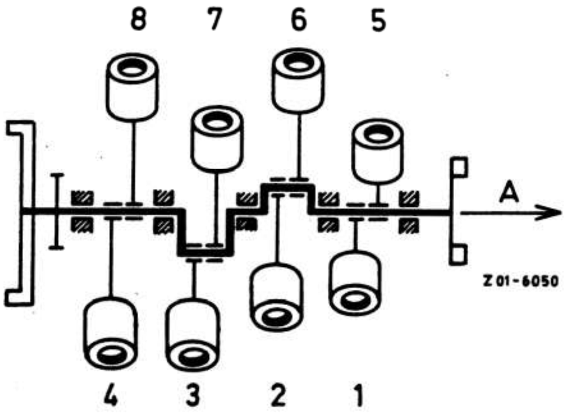
In particular cases, the output ratings depend upon the application, while taking all operating conditions into account.

Continuous operating engine speeds below 1500 rpm on request.



OM 442 LA Industrial engine

Engine model	442.901–500
Engine output to 80/1269/EEC	331 kW (450 HP)
Maximum torque to DIN	1765 Nm
Nominal speed	2100 rpm
Number of cylinders	8
Bore	128 mm
Stroke	142 mm
Total displacement	14.618 cm^3



Arrangement of pistons and cylinders A = Fan end

Operation	Diesel 4-stroke
Start of delivery	14° before TDC
Compression	16.25
Firing sequence	1–5–7–2–6–3–4–8
Valve overlap	6–3–4–8–1–5–7–2
Compression at approx. 120 rpm	min. 20 bar
Valve clearance inlet	0.40 mm
exhaust	0.60 mm

Injection pressure of injection nozzles	
new	200 + 8 bar
used	min. 175 bar
Engine oil capacity	
Oil pan with oil filter	max. approx. 27 l min. approx. 19.5 l
Minimum oil pressure at	
Max. engine speed	2.5 bar
Idle speed	0.5 bar

80/1269/EEC

Max. vehicle output ————

The power output is made available at the flywheel of the engine. The power requirements of the standard fan are already taken into account.

DIN 6271

Max. blocked
ISO effective output **IFN** — – — – —
(substitutes output B DIN 6270)

ISO standard output
ICXN — — —
can be exceeded by 10%
(substitutes continuous output A DIN 6270)

Deviating from the Standard DIN 6271, the power requirements of a fan are not taken into consideration in the outputs IFN and ICXN due to the wide variety of cooling systems.

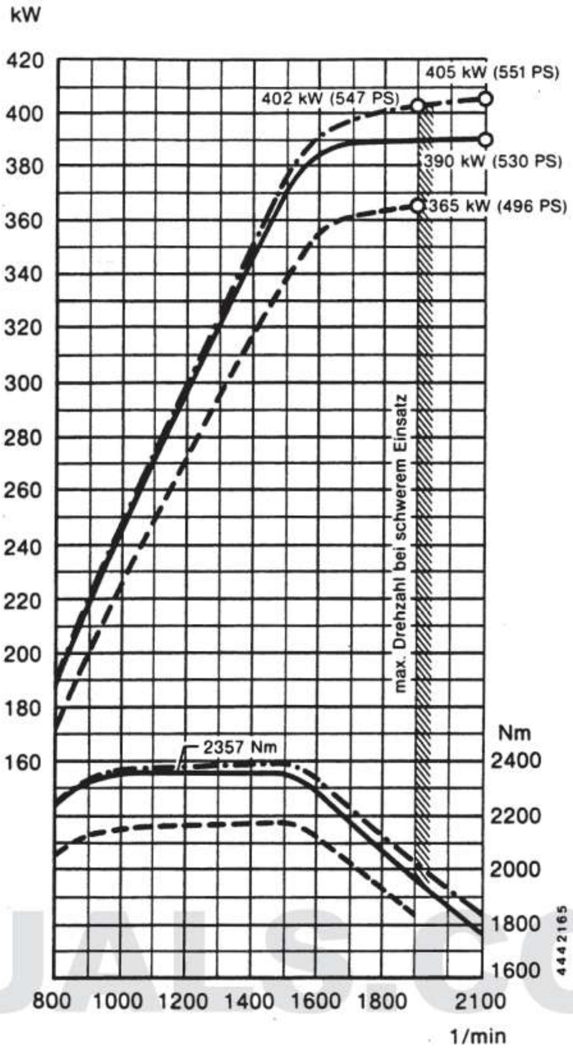
The blocked ISO effective output **IFN** cannot be exceeded., it is permissible for the duration of 1 hour continuously or interrupted within a period of 6 hours.

The ISO standard output **ICXN** is a continuous output and can be exceeded by 10%. The excess output is blocked and is permissible continuously for the duration of 1 hour or interrupted within a period of 12 hours.

The output ratings and the specific fuel consumption refer to a diesel fuel with a reference density p15 = 0.84 g/cm^3 and a temperature at inlet in the injection pump of 35° C.

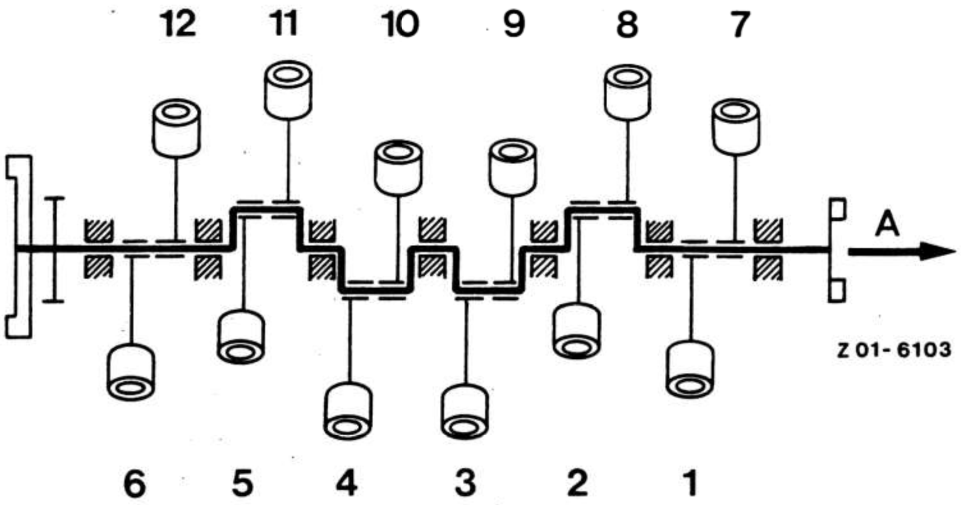
In particular cases, the output ratings depend upon the application, while taking all operating conditions into account.

Continuous operating engine speeds below 1500 rpm on request.



OM 444 A Industrial engine

Engine model	444.901–400
Engine output to 80/1269/EEC	407 kW (553 HP)
Maximum torque to DIN	2357 Nm
Nominal speed	2100 rpm
Number of cylinders	12
Bore	128 mm
Stroke	142 mm
Total displacement	21.930 cm^3



Arrangement of pistons and cylinders A = Fan end

Operation	Diesel 4-stroke
Start of delivery	14° before TDC
Compression	16.25
Firing sequence	1–12–5–8–3–10–6–7–2–11–4–9
Valve overlap	6–7–2–11–4–9–1–12–5–8–3–10
Compression at approx. 120 rpm	min. 20 bar
Valve clearance inlet	0.40 mm
exhaust	0.60 mm

Injection pressure of injection nozzles	
new	200 + 8 bar
used	min. 175 bar
Engine oil capacity	
Oil pan with oil filter	max. approx. 33.5 l min. approx. 23.5 l
Minimum oil pressure at	
Max. engine speed	2.5 bar
Idle speed	0.5 bar

80/1269/EEC

Max. vehicle output ————

The power output is made available at the flywheel of the engine. The power requirements of the standard fan are already taken into account.

DIN 6271

Max. blocked
ISO effective output **IFN** — - — - —
(substitutes output B DIN 6270)

ISO standard output
ICXN — — —
can be exceeded by 10%
(substitutes continuous output A DIN 6270)

Deviating from the Standard DIN 6271, the power requirements of a fan are not taken into consideration in the outputs IFN and ICXN due to the wide variety of cooling systems.

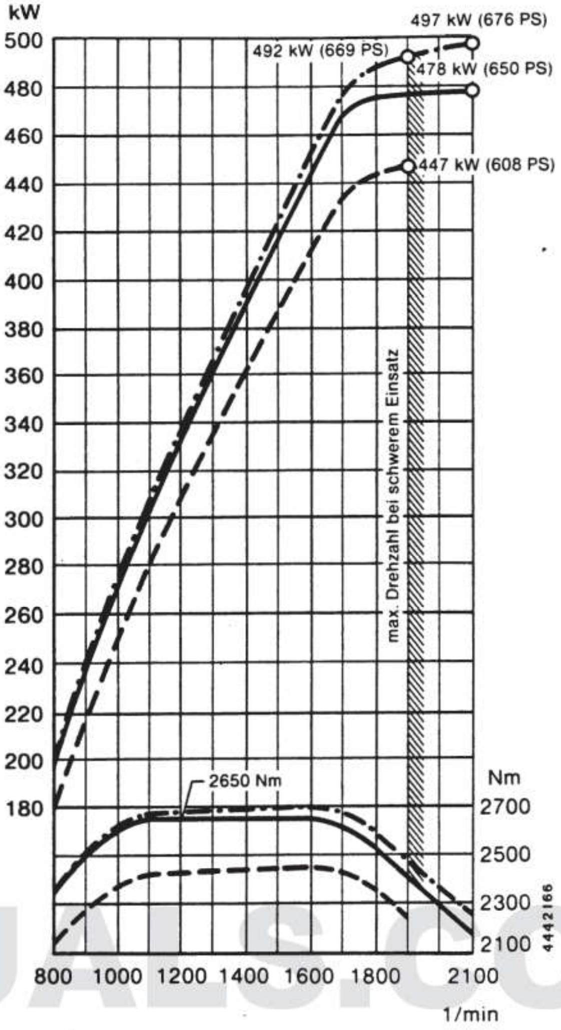
The blocked ISO effective output **IFN** cannot be exceeded, it is permissible for the duration of 1 hour continuously or interrupted within a period of 6 hours.

The ISO standard output **ICXN** is a continuous output and can be exceeded by 10%. The excess output is blocked and is permissible continuously for the duration of 1 hour or interrupted within a period of 12 hours.

The output ratings and the specific fuel consumption refer to a diesel fuel with a reference density p15 = 0.84 g/cm^3 and a temperature at inlet in the injection pump of 35° C.

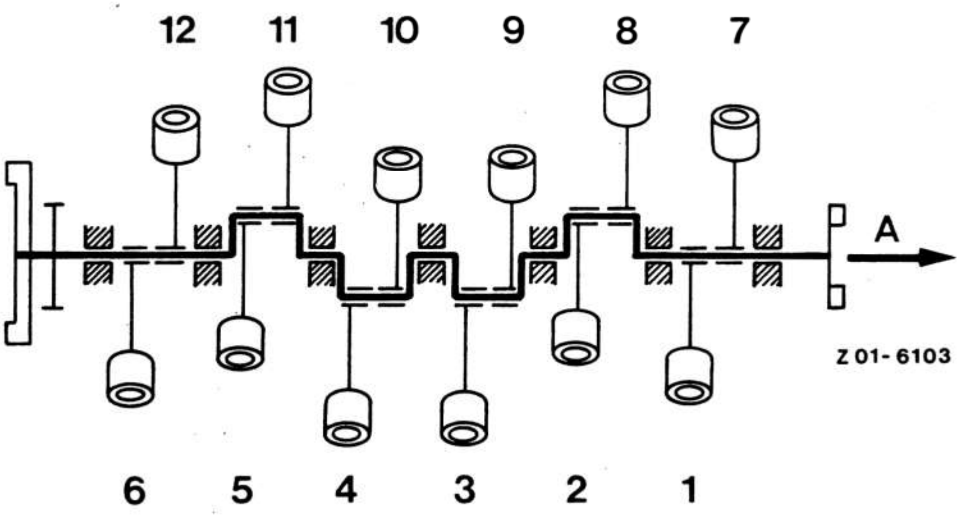
In particular cases, the output ratings depend upon the application, while taking all operating conditions into account.

Continuous operating engine speeds below 1500 rpm on request.



OM 444 LA Industrial engine

Engine model	444.901–500
Engine output to 80/1269/EEC	496 kW (674 HP)
Maximum torque to DIN	2650 Nm
Nominal speed	2100 rpm
Number of cylinders	12
Bore	128 mm
Stroke	142 mm
Total displacement	21.930 cm^3



Arrangement of pistons and cylinders A = Fan end

Operation	Diesel 4-stroke
Start of delivery	14° before TDC
Compression	16.25
Firing sequence	1–12–5–8–3–10–6–7–2–11–4–9
Valve overlap	6–7–2–11–4–9–1–12–5–8–3–10
Compression at approx. 120 rpm	min. 20 bar
Valve clearance inlet	0.40 mm
exhaust	0.60 mm

Injection pressure of injection nozzles	
new	200 + 8 bar
used	min. 175 bar
Engine oil capacity	
Oil pan with oil filter	max. approx. 33.5 l min. approx. 23.5 l
Minimum oil pressure at	
Max. engine speed	2.5 bar
Idle speed	0.5 bar

80/1269/EEC

Max. vehicle output ━━━━━━━━

The power output is made available at the flywheel of the engine. The power requirements of the standard fan are already taken into account.

DIN 6271

Max. blocked
ISO effective output **IFN** ━━ · ━━ · ━━
(substitutes output B DIN 6270)

ISO standard output
ICXN ━━ ━━ ━━
can be exceeded by 10%
(substitutes continuous output A DIN 6270)

Deviating from the Standard DIN 6271, the power requirements of a fan are not taken into consideration in the outputs IFN and ICXN due to the wide variety of cooling systems.

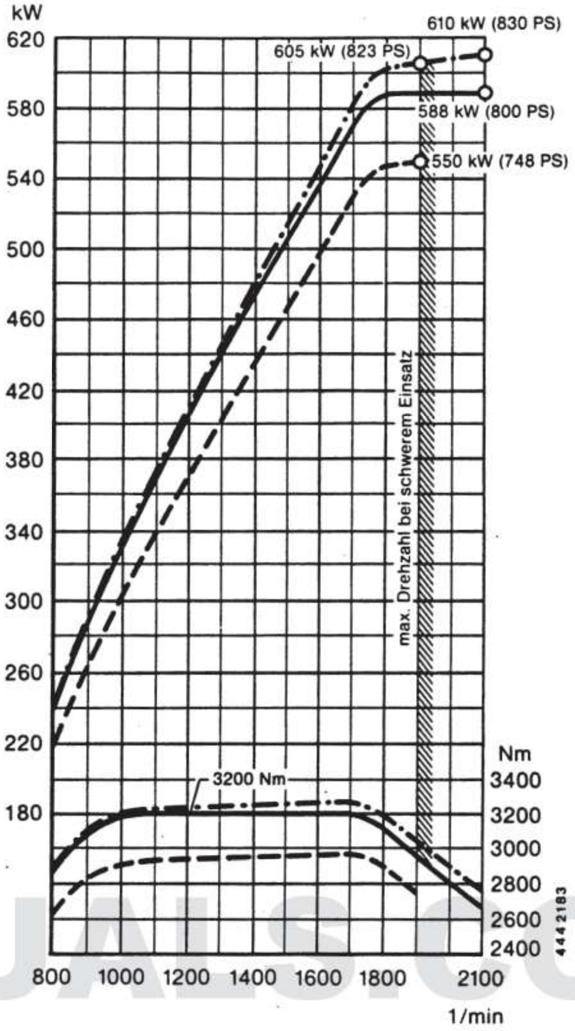
The blocked ISO effective output **IFN** cannot be exceeded, it is permissible for the duration of 1 hour continuously or interrupted within a period of 6 hours.

The ISO standard output **ICXN** is a continuous output and can be exceeded by 10%. The excess output is blocked and is permissible continuously for the duration of 1 hour or interrupted within a period of 12 hours.

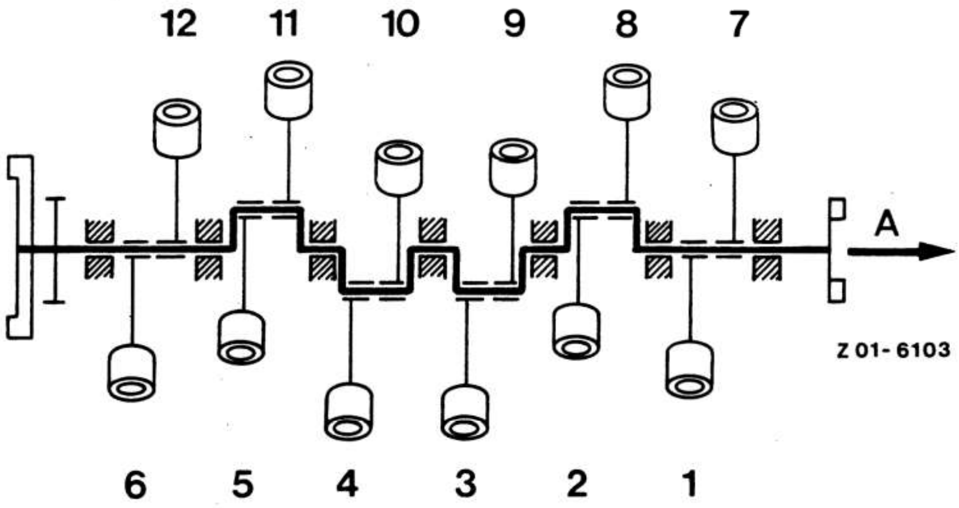
The output ratings and the specific fuel consumptioon refer to a diesel fuel with a reference density p15 = 0.84 g/cm^3 and a temperature at inlet in the injection pump of 35° C.

In particular cases, the output ratings depend upon the application, while taking all operating conditions into account.

Continuous operating engine speeds below 1500 rpm on request.



OM 444 LA	**Industrial engine**
Engine model	444.901–501
Engine output to 80/1269/EEC	610 kW (830 HP)
Maximum torque	3200 Nm
Nominal speed	2100 rpm
Number of cylinders	12
Bore	128 mm
Stroke	142 mm
Total displacement	21.930 cm^3



Arrangement of pistons and cylinders A = Fan end

Operation	Diesel 4-stroke
Start of delivery	13° before TDC
Compression	14.25
Firing sequence	1–12–5–8–33–10–6–7–2–11–4–9
Valve overlap	6–7–2–11–4–9–1–12–5–8–3–10
Compression at approx. 120 rpm	min. 17 bar
Valve clearance inlet	0.40 mm
exhaust	0.60 mm

Injection pressure of injection nozzle	
new	200 + 8 bar
used	min. 175 bar
Engine oil capacity	
Oil pan with oil filter	max. approx. 33.5 l min. approx. 23.5 l
Minimum oil pressure at	
Max. engine speed	2.5 bar
Idle speed	0.5 bar

00 – 0010 Tightening Torques in Nm

Group	Description	Torque
01	Central bolts for crankshaft bearing caps	1)
	Side bolts crankshaft bearing caps	80
	Oil separator to crankcase	8
	Oil pan to crankcase	30 8)
	Oil drain plug to oil pan	80
	Oil filler tube to oil pan	25
	Screw coupling, oil dipstick guide tube to oil pan	50
	Cover on timing case and crankcase	25 7)
	Timing case to crankcase M 12 x 1.5	100
	Timing case to crankcase M 10	60
	Cover to crankcase, front	25
	Screw plug, oil duct flywheel end M 30x1.5	150
	Screw plug, oil duct fan end M 30x1.5	150
	Screw plug, main oil duct and connection duct fan end M 25x1.5, 10.9	120
	Screw plug, oil duct flywheel end M 30x1.5	200
	Screw plug, oil duct fan end M 30x1.5, 12.9	200
	Screw plug, main oil duct and connection duct fan end M 26x1.5, 12.9	200
	Screw plug, oil supply PTO M 18x1.5	80
	Screw plug, oil supply turbocharger M 14x1.5	50
	Screw plug, temperature sensor M 14x1.5	50
	Screw plug, coolant supply and return, compressor M 14x1.5	50
	Coolant drain plug M 14x1.5	50
	Screw plug, top coolant channel M 26x1.5	120
	Lock nut, camshaft bore hole M 22x1.5	100
	Thrust washer to timing case	25
	End cover, compressor opening on timing case	30
	Starter mounting to timing case	80
	Screw plug, inspection hole start of delivery M 26x1.5	80
	Screw plug, inspection hole start of delivery M 38x1.5	100
	Cover, TDC inspection hole on timing case	25
	Screw plug, cored hole cylinder head M 22x1.5	100
	Cylinder head to crankcase	2)
	Cylinder head cover	25
	Screw coupling, vent crankcase – coolant channel, right M 14x1.5	50
	Guide tube, oil dipstick to oil pan	35
	Tachometer, front end of camshaft	35
03	Counterweight to crankshaft	6)
	Hub, pulley to crankshaft	200
	Vibration damper to crankshaft	200
	Pulley to hub	25
	Pulley to vibration damper	25
	Connecting rod to crankshaft	3)
	Flywheel to crankshaft	5)
	Crown gear carrier to crankshaft	5)
05	Rocker arm bracket to cylinder head	75
	Lock nut to adjusting screw	50
	Adjustment segment to camshaft wheel	50

For footnotes see 00.3 – 0010/5

Group	Description	Torque
07	Drive gear to injection pump	35
	Injection pump to crankcase	50
	Injection delivery lines to injection pump and injection nozzle	25
	Securing clip for injection lines	10
	Mount tube to crankcase M 16	150
	Mount tube to crankcase M 10	50
	Lock nut, drawbar injection pump	8
	Lock nut, stop pin intermediate speed M 8	20
	Lock nut, adjusting sleeve intermediate speed M 22x1.5	30
	Lock nut, full load limit stop injection pump M 6	5
	Retaining cap for full load lead seal M 6	5
	Connection line, charge air tube	25
	Fuel filter to holder	80
	Holder for fuel filter to timing case cover	80
	Filter bowl to cover	15
	Fuel lines to delivery pump, filter and injection pump	30
	Bleeder screw for fuel filter	15
	Nozzle in nozzle holder	75
	Thrust bolt nozzle holder to cylinder head	70
	Holder for fuel prefilter to cross intake tube	25
09	Charge air tube to cylinder head	25
	Cross connection to charge air tubes	50
	Connection, charge air tubes	50
	Turbocharger to exhaust manifold	50
	Air intake tube to bracket M 10	50
	Air intake tube to bracket M 8	25
	Crankcase vent connection to air intake tube	80
13	Screw plugs to compressor cylinder head	80
	Socket coupling for coolant supply to cylinder head	50
	Socket coupling for coolant supply and return to crankcase	50
	Socket coupling for coolant return to cylinder head	80
	Socket coupling for compressed air to cylinder head	80
	Socket coupling for intake air to cylinder head	80
	Pressure plate to intermediate plate	50
	Intermediate plate to cylinder head	30
	Drive gear to compressor crankshaft	360[4])
	Connecting rod to compressor crankshaft	30
	Cylinder liner to timing case M 8, 10.9	30
	Cylinder head to cylinder liner	30
	Power steering pump to timing case	60
	Coolant line to socket coupling	35
	Bearing cover to timing case	25
	Mounting flange for ball bearing to bushing	50

For foot notes, see 00.3 – 0010/5

Group	Description	Torque
14	Exhaust manifold to cylinder head	50
	Intake tube to cylinder head	30
	Charge air tube to cylinder head 10.9	30
	Screw plug, start pilot	30
	Start pilot nozzle lock nut	30
	Cross intake tube to intake tube	50
	Retaining plate, engine brake to exhaust manifold	25
	Lever to shaft, throttle valve	15
	Bracket, engine brake left to timing case M 16	150
	Bracket, engine brake right to intake tube M 10	50
	Pivot pin for working cylinder to bracket	25
	Lock nut, working cylinder piston rod	20
	Bracket to valve coupling	35
	Valve coupling, engine brake to exhaust turbocharger M 10	50
	Working cylinder to pivot pin	10
	Screw plug in intake tube, right M 26	50
15	Alternator bracket to crankcase cylinder head	160
	Alternator to bracket	50
	Clamping piece, tensioning screw to alternator	35
	Tensioning screw to oil pan	50
	Fan pulley to alternator	50
	Cover plate to alternator	50
	Starter to timing case	80
	Pulley to alternator	150
18	Oil pressure control valve to oil pump	35
	Oil pump to crankcase	35
	Cover to oil pump	25
	Intake tube to oil pump	35
	Intake tube to crankcase	35
	Oil spray nozzle to crankcase (piston spray)	47
	Oil cooler to oil filter head	25
	Bypass valve, oil filter	60
	Oil filler screw plug to oil filter head	80
	Oil drain plug to oil filter bowl	50
	Oil filter bowl to oil filter head	50
	Oil filter with oil cooler to crankcase	70
	Coolant drain plug to oil cooler	50
	Oil cooler cover to auxiliary cooler housing	25
	Screw plug, oil duct auxiliary oil cooler	80
	Oil delivery line to turbocharger	25
	Oil delivery line to crankcase	25
	Oil return pipe elbow to turbocharger	25
	Oil return socket coupling to timing case, right	120
	Lock nut, oil return to timing case, left	30
	Shield plate to timing case	150

Group	Description	Torque
20	Coolant pump to crankcase	25
	Coolant outlet to coolant pump M 8	25
	Coolant inlet to coolant pump M 10	50
	Pulley to coolant pump	25
	Rigid fan to flexible hub	30
	Visco-drive fan with intermediate piece and pulley to hub	30
	Visco-drive fan with intermediate piece and pulley to vibration damper	30
	Fan bracket to crankcase	60
	Tensioning arm to fan bracket	80
	Tensioning screw to fan bracket	50
	Clamping piece for tensioning screw to tensioning arm	80
	Fan body to engine mount	50
	Fan body to oil pan	50
	Bracket to fan body	50
	Visco-drive fan to pulley hub	30
22	Front engine mount to crankcase	110
	Front mount lug to crankcase M 20	330
	Front mount lug to crankcase M 10	50
	Rear mount lug to timing case	150
23	Bearing housing and bearing flange to timing case	25
	Output flange to PTO shaft	300
	Drive gear to PTO	300
	Oil supply for PTO (oil nozzle)	80
	Bearing housing to timing case	25

Remarks:

[1] Tighten in 4 stages:
1st. stage 100 Nm
2nd. stage 200 Nm
3rd. stage 300 to 330 Nm
4th. stage (tightening angle)
90° to 100° final torque

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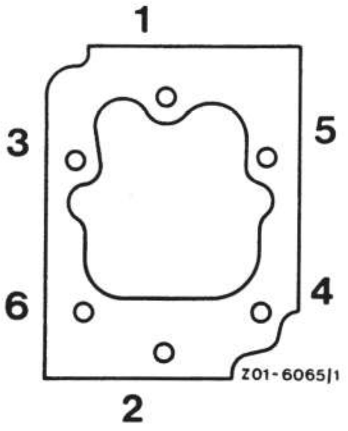
[2] Tighten in 6 stages:
1st. stage 10 Nm
2nd. stage 50 Nm
3rd. stage 100 Nm
4th. stage 140 to 150 Nm
5th. stage 180 to 190 Nm
6th. stage (tightening angle)
90° to 100° final torque



Tightening diagram cylinder head

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[3] Initial torque 100 Nm
Final torque 90° to 100° tightening angle

[4] With special tool 442 589 00 03 00, 270 Nm

[5] Initial torque 200 to 220 Nm
Final torque 90° to 100° tightening angle

[6] Initial torque 140 to 150 Nm
Final torque 90° to 100° tightening angle

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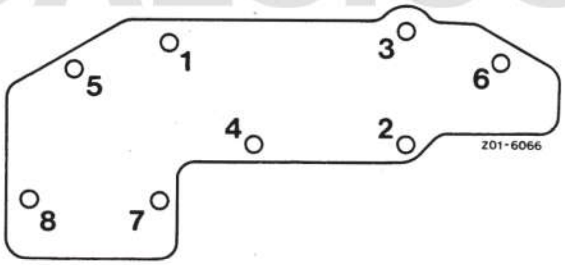
[7] Tightening diagram, timing case cover



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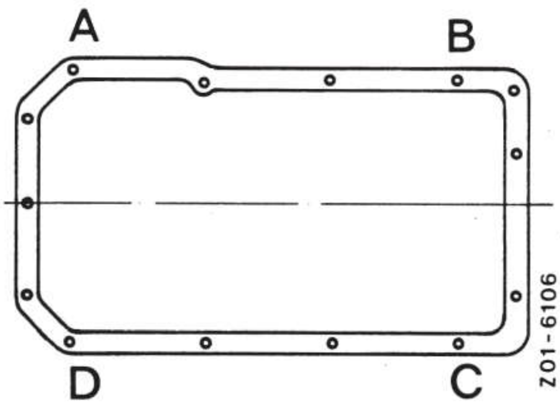
[8] Tightening diagram, oil pan

a) Tighten corner bolts crosswise A–C and B–D to 30 Nm.

b) Tighten remaining bolts in their order about the periphery to 30 Nm (starting from the last tightened corner bolt).

c) Retighten corner bolts to 30 Nm.



00 – 0901 Repairing Threaded Holes with Heli-Coil Inserts

Metric thread	Cored hole dia.	Outside dia. twist drill
M 6	6,31 6,04	6,1–6,2–6,25
M 8	8,35 8,04	8,1–8,2–8,25–8,3
M 8 x 1	8,32 8,04	8,1–8,2–8,25–8,3
M 10	10,40 10,05	10,25
M 12	12,50 12,05	12,25–12,5
M 12 x 1,5	12,43 12,05	12,25
M 14	14,53 14,06	14,25–14,5
M 14 x 1,5	14,43 14,05	14,25
M 15 x 2	15,30 15,20	15,25
M 16	16,53 16,06	16,25–16,5
M 16 x 1,5	16,43 16,05	16,25
M 24 x 1,5	24,43 24,05	24,25
M 26 x 1,5	26,43 26,05	26,25
M 30 x 1,5	30,43 30,05	30,25

Special Tools

Heli-coil tool box M 6, M 8, M 10, M 12, M 14	000 589 03 28 00
Heli-coil tool box M 8 x 1, M 12 x 1.5, M 14 x 1.5, M 14 x 1.25	000 589 04 28 00
Heli-coil tool box M 15 x 2	000 589 05 28 00
Heli-coil tool box M 16 x 1.5	000 589 06 28 00
Heli-coil tool box M 18 x 1.5	000 589 07 28 00
Heli-coil tool box M 24 x 1.5	000 589 08 28 00
Heli-coil tool box M 26 x 2.5	000 589 09 28 00
Heli-coil tool box M 16	000 589 10 28 00
Heli-coil cool tool box M 30 x 1.5	000 589 11 28 00

Repairing

1 Drill out cored hole with twist drill

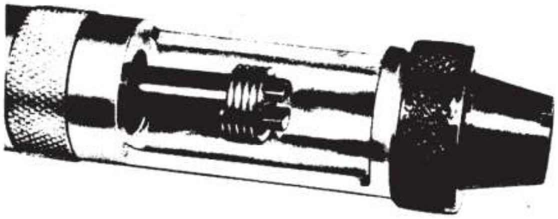
2 Recut the damaged thread with the special heli-coil screw tap.

3 Use corresponding mouth piece and spindle for the thread.

R 0–6026

4 Insert heli-coil thread insert in the chamber of the installer.

Note: The retaining pin of the heli-coil insert must rest on the mouth piece.



R 0–6027

5 Turn thread insert with spindle through mouth piece until it is flush at the front.

R0-6028

6 Rest installer on the threaded hole and turn in insert without exerting pressure on the spindle.

Note: Turn in insert ½ to 1½ turns deeper than the surface of the threaded hole.

7 Remove retaining pins up to M 12 by means of a short powerful blow with the pin breaker. In the case of threaded inserts over M 12 remove retaining pin by bending up and down (not to and fro) with pointed nose pliers.

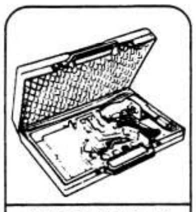
R0-6029

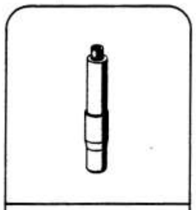
01 – 1200 Checking Compressing

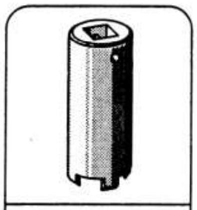
Data

Compression at approx. n = 120 to 200 rpm	min. 20 bar
Pressure difference of the individual cylinder	max. 4 bar
Industrial engine 444.901–501	
Compression at approx. n = 120 rpm to 200 rpm	min. 17 bar

Special tools


001 589 78 21 00


403 589 00 21 00


403 589 04 07 00

Preparatory work

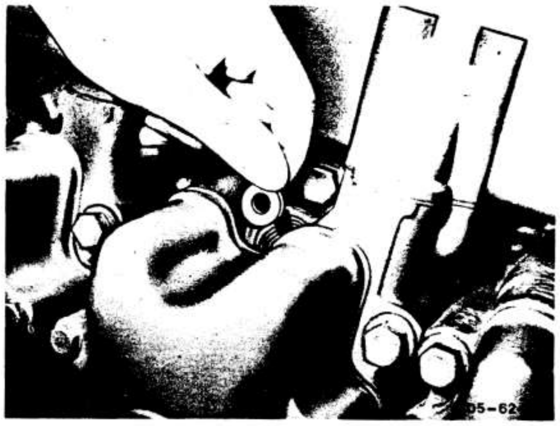
1 Check valve clearance and adjust if necessary.

2 Run engine to normal operating temperature (70–95° C).

3 Remove nozzle holder with nozzle.

Checking

1 Place sealing ring on sealing surface in cylinder head for nozzle holder.



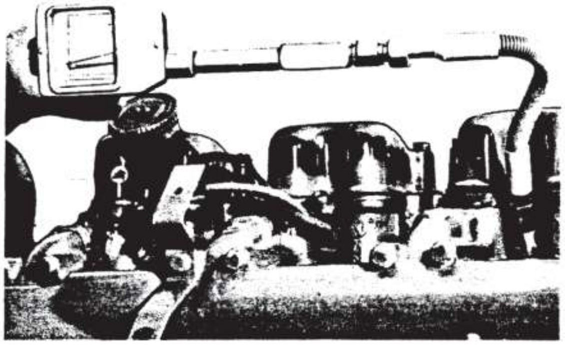
2 Insert connection piece in the cylinder head and tighten thrust bolt with special wrench.

Connection piece 403 589 00 21 00

3 Screw compression tracer with extension to connection piece.

4 Check compression at an engine speed of 120–200 rpm (starter speed) and the injection pump completely switched off. Turn engine until the pointer no longer rises.

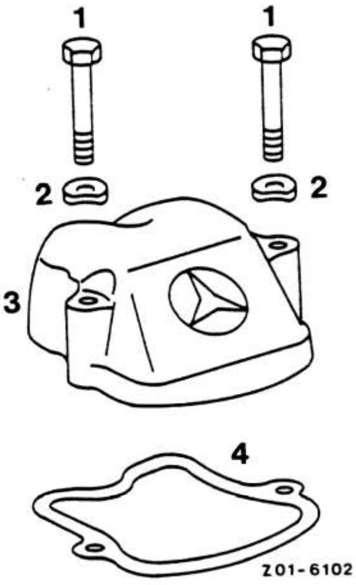
Compression tracer 001 589 78 21 00



Note: If the compression is less than 20 bar (or 17 bar for industrial engine 444.901–501) and if the pressure difference of the individual cylinders is greater than 4 bar, the cylinder heads must be removed in order to check the valve seats and the cylinder bores.

5 Remove compression tracer and connection piece. Remove sealing ring from the sealing surface in the cylinder head.

01 – 5014 Removal and Installation of Cylinder Head Cover

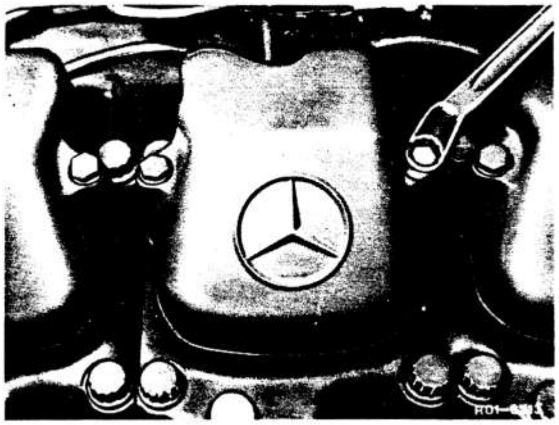


1	Bolt	25 Nm
2	Spring washer	
3	Cylinder head cover	
4	Gasket	renew

Removal

1 Slacken and unscrew the bolts holding the cylinder head cover. Remove cylinder head cover.

2 Remove cylinder head cover gasket.

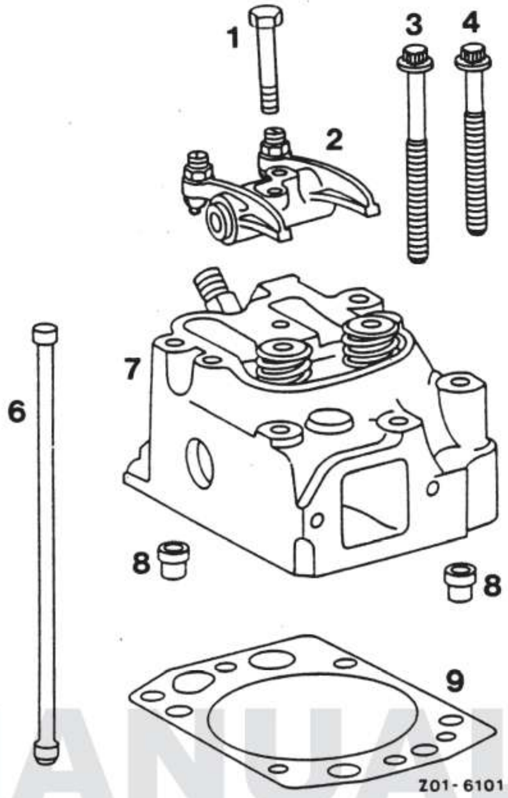


Installation

1 Fit new cylinder head cover gasket.

2 Fit cylinder head cover and tighten securing bolts to 25 Nm.

01 – 6110 Removal of Cylinder Head



1	Rocker arm bolt	
2	Rocker arm	
3	Cylinder head bolt	Special tool 422 589 00 09 00
4	Cylinder head bolt	Special tool 422 589 00 09 00
5	Cylinder head bolt	Special tool 403 589 02 03 00
6	Push rod	
7	Cylinder head	remove to the side
8	Fitted sleeve	
9	Cylinder head gasket	

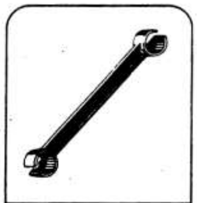
Preparatory work

Drain coolant.

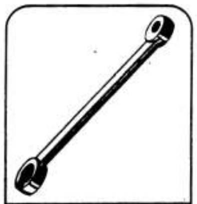
Remove intake tube.

Remove exhaust manifold.

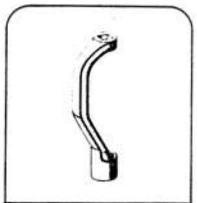
Special tools



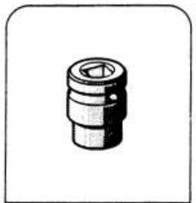
000 589 07 03 00



000 589 50 03 00



403 589 02 03 00



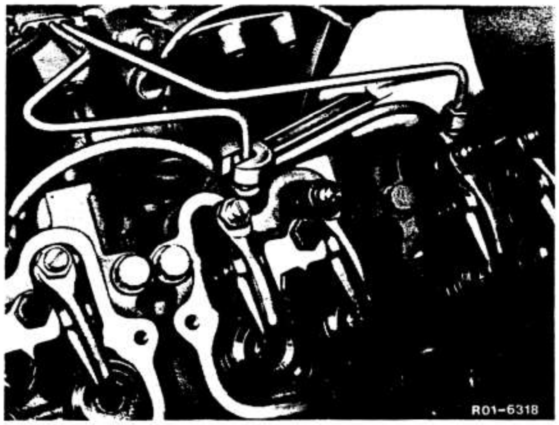
422 589 00 09 00

Removing cylinder head

1 Remove cylinder head covers.

2 Using special wrench, unscrew union nut of the injection lines at the nozzle holder.

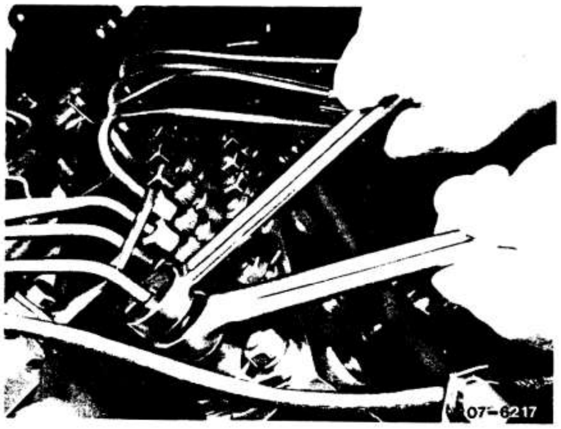
Special tool 000 589 07 03 00



3 Using special wrench, unscrew the union nut of the injection lines at the injection pump while holding the pipe connection with the other special tool.

Note: Bending of the injection lines must be avoided on all accounts.

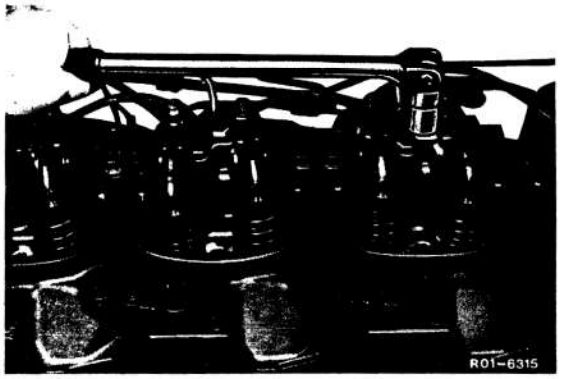
Special wrench 000 589 07 03 00
Special wrench 000 589 50 03 00



4 Detach leakage fuel line from nozzle holder.

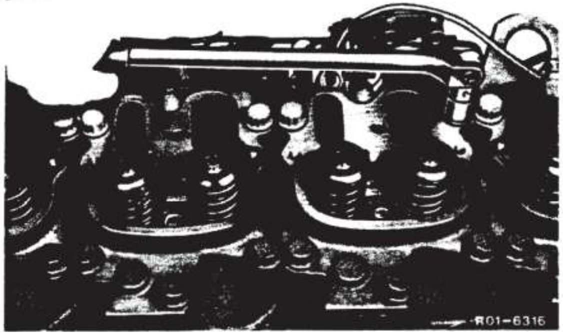
5 Unscrew rocker arm bracket and remove.

6 Remove push rods from the crankcase.



7 Slacken and unscrew cylinder had bolts.

Socket wrench insert 422 589 00 09 00

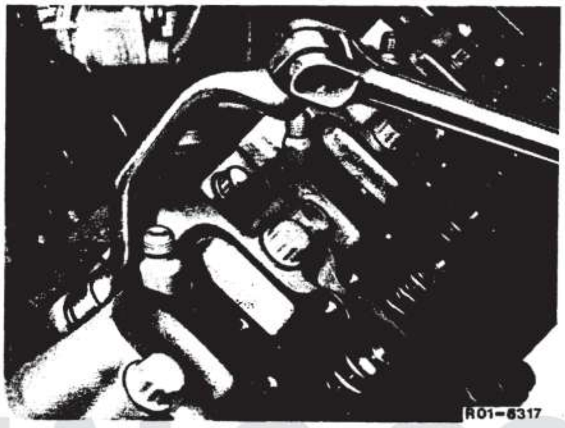


Note: The cylinder head bolts beneath the nozzle holder can be loosened with the special wrench. However, it cannot be removed from the cylinder head.

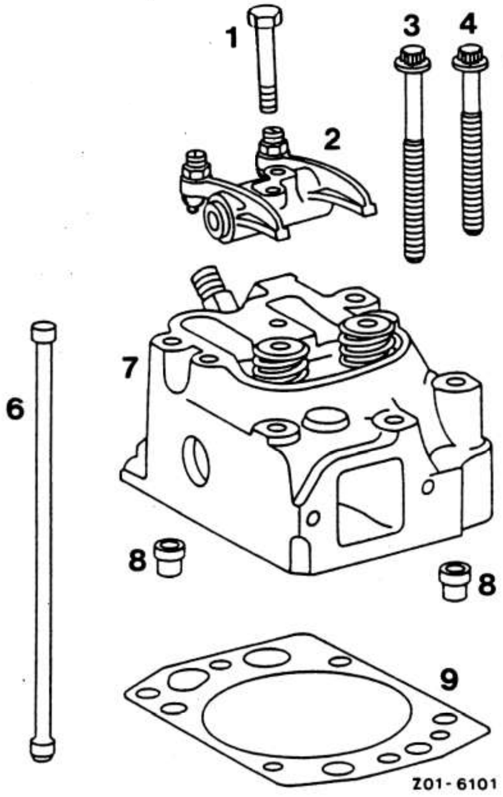
8 Remove cylinder head.

Note: When the injection nozzle is installed, always remove cylinder head to the side. The nozzle juts out at the bottom of the cylinder head.

Special wrench 403 589 02 03 00



01 – 6160 Installation of Cylinder Head



1 Rocker arm bolt	85 Nm
2 Rocker arm	
3 Cylinder head bolt	Special tool 422 589 00 09 00
Elongation: can be reused up to shank length.	max. 170 mm
4 Cylinder head bolt	Special tool 422 589 00 09 00
Elongation: can be reused up to shank length.	max. 146 mm
5 Cylinder head bolt	Special tool 403 589 02 03 00
Elongation: can be reused up to shank length.	max. 111 mm
Tighten cylinder head bolts in 6 stages:	1st. stage 10 Nm 2nd. stage 50 Nm 3rd. stage 100 Nm 4th. stage 140 to 150 Nm 5th. stage 180 to 190 Nm 6th. stage 90° to 100° tightening angle
6 Push rod	
7 Cylinder head	refer to tightening diagram
8 Centering sleeve	
9 Gasket	renew

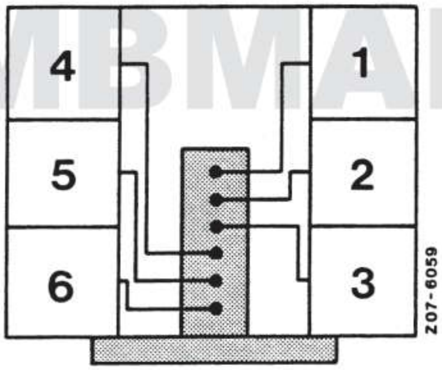
Tightening torques in Nm

Injection lines to pump and nozzle	25
Intake tube	30
Cylinder head cover	25
Exhaust manifold	50

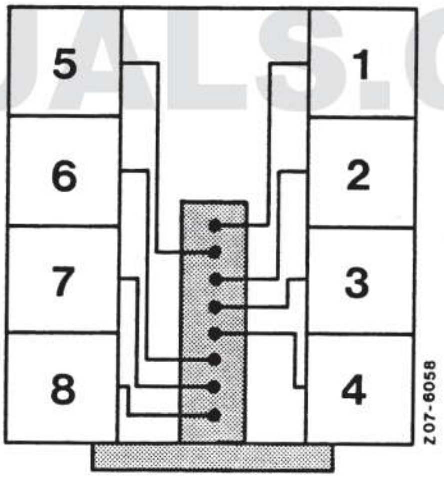
Cylinder head

Total height of cylinder head when new	114.00 113,90
Permissible material removal to minimum height	113.4
Permissible unevenness of the lower mating surface over a length of 150 mm	0.015
Permissible deviation in parallel alignment of the upper mating surface with respect to the lower mating surface	0.1
Check cylinder head for leaks under water with compressed air	2.5 bar overpressure
Nozzle projection	1.6–2.4

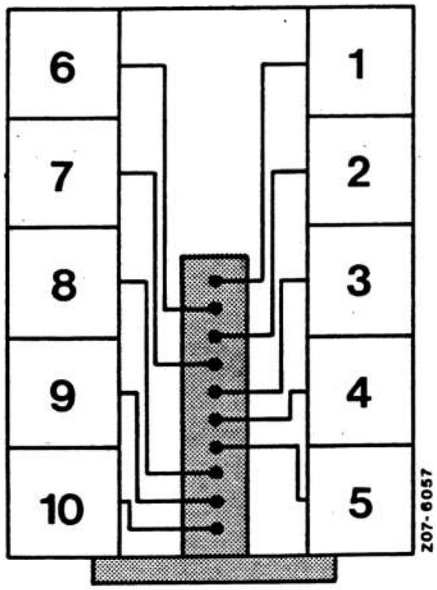
Arrangement of the injection lines



OM 441
OM 441 LA



OM 442
OM 442 A
OM 442 LA


6
1
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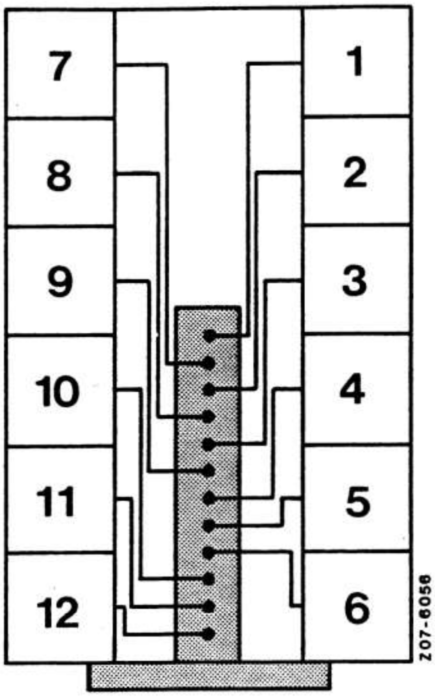
Z07-6057

OM 443
OM 443 LA


7
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Z07-6056

Industrial engine
OM 444 A
OM 444 LA

Special tools

000 589 68 03 00

000 589 50 03 00

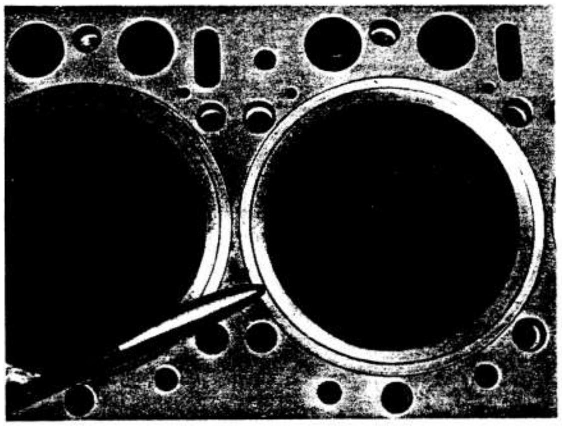
403 589 02 03 00

422 589 00 09 00

Installing cylinder head

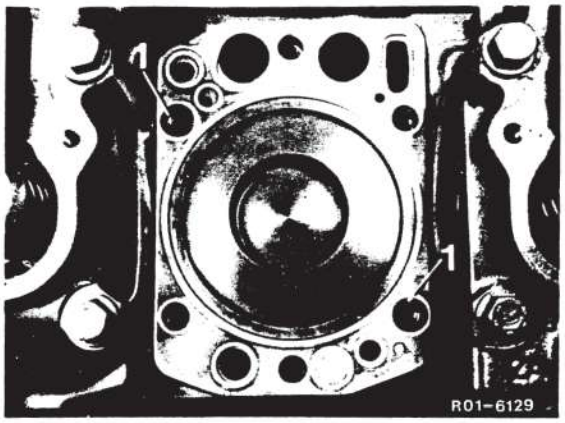
1 Before fitting the cylinder heads, thorougly clean threaded holes in the crankcase. Remains of any water which may have entered the hole must be removed on all accounts.

2 Clean cylinder head mating surface and flat surface of the crankcase.



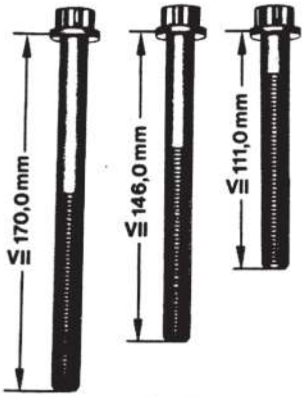
3 Place new cylinder head gasket over the fitted sleeves onto the flat surface of the crankcase.

1 = Fitted sleeve



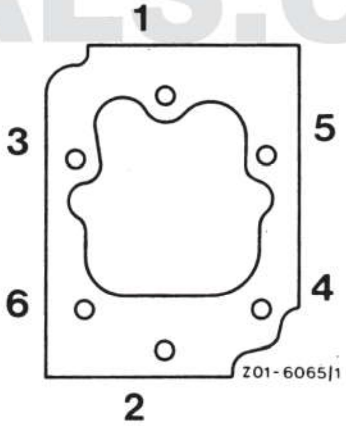
4 Carefully place cylinder head on the cylinder head gasket.

5 Measure shank length of the cylinder head bolts.



6 Lightly oil cylinder head bolts, screw in and tighten in 6 stages in the specified order

1st. stage 10 Nm
2nd. stage 50 Nm
3rd. stage 100 Nm
4th. stage 140 to 150 Nm
5th. stage 180 to 190 Nm
6th. stage 90° to 100° tightening angle



Note 1: Use special wrench for the bolt beneath the nozzle holder.

Note 2: If one bolt is over tightened during installation, all 6 bolts of the cylinder head concerned must be slackened off, their elongation checked and retightened starting with stage 1.

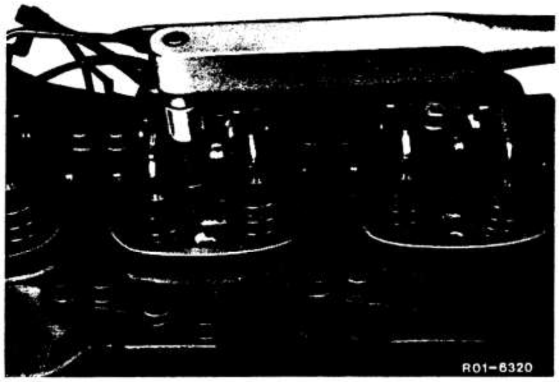
Special wrench	403 589 02 03 00
Socket wrench insert	422 589 00 09 00

7 Fit push rods.

8 Place rocker arm bracket in position and slightly tighten bolts. Align rocker arms with respect to the valves.

9 Firmly tighten rocker arm bracket with torque wrench to 75 Nm.

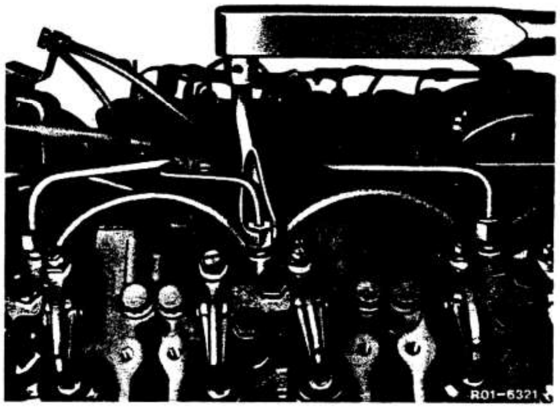
10 Adjust valves.



11 Install injection lines and firmly tighten at nozzle holder and injection pump to 25 Nm.

12 Mount cylinder head covers.

Special tool 000 589 68 03 00



Note: Hold thrust nut of injection pump with special tool.

13 Connect leakage fuel line at nozzle holder.

Note: The cylinder head bolts are not retightened.

Special wrench 000 589 68 03 00
Special wrench 000 589 50 03 00

01 – 7162 Refacing Cylinder Head

Data

Total height of cylinder head	$\frac{114.0}{113.9}$
Possible total material removal to the minimum height of 1)	113.4
Peak-to-valley height of mating surface in μm	0 – 16
Impermissible unevenness of lower mating surface over a length of 150 mm	0.015
Permissible deviation in parallel alignment of the upper mating surface with respect to the lower mating surface	0.1
Nozzle projection	1.6 – 2.4
Valve recess	0.7 – 1.1

---

1) After machining the cylinder head surface, the nozzle projection must be checked and corrected with nozzle shims if necessary.

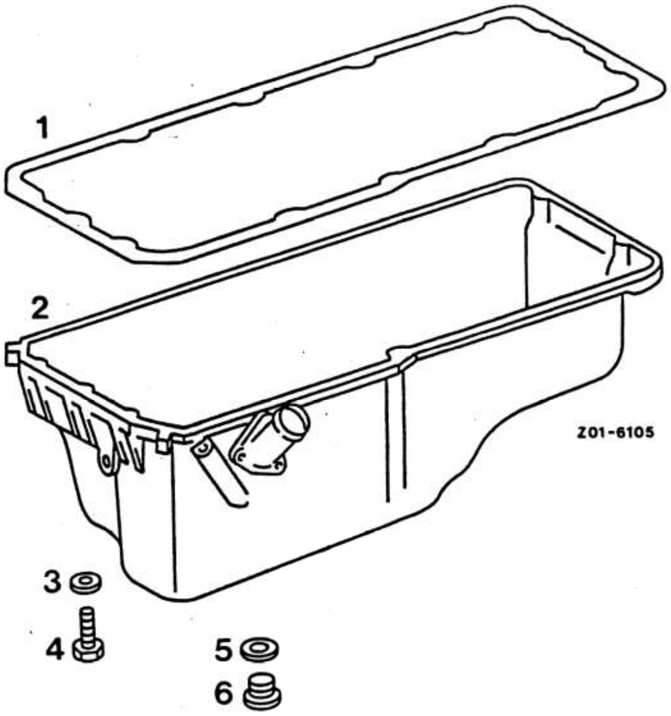
We recommend that the following data are complied with in order to achieve the specified peak-to-valley height during grinding:

Necessary segments:	
Form:	DA 19
Dimensions:	79/70 x 21 x 80
Specification:	50C 36F 5V 15
Manufacturer:	Tyrolit Schleifmittelgesellschaft
Supply sources domestic:	Heidemannstr. 166e 8000 Munich 45
Machine setting values	
Speed:	$n = 1400$ rpm
Feed rate:	$u = 920$ mm/min
Cutting speed:	$V_s = 27$ m/s

The specified cutting speed is referred to a segment grinding wheel diameter of 370 mm. In the case of other diameters (depending on machine type) the speed must be changed such that $V_s = \frac{d \cdot \geqq \cdot n}{1000 \cdot 60} = 27$ m/s deviates by no more than ± 10%.

Important: In the case of small feed steps or manual feed, the grinding pattern is changed considerably and the peak-to-valley height of $R_z = 0 - 16\ \mu$m can no longer be achieved with the required degree of reliability.

01 – 7500 Removal and Installation of Oil Pan



1	Gasket	renew
2	Oil pan	
3	Washer	
4	Bolt	refer to tightening diagram 30 Nm
5	Sealing ring	renew
6	Oil drain plug	80 Nm

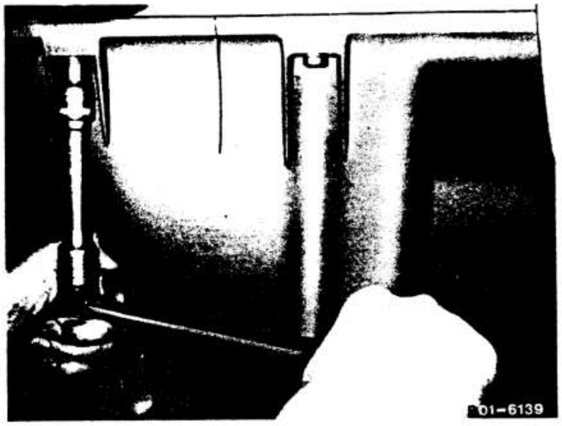
Removal

1 Drain engine oil.

2 Unscrew oil filler tube and oil dipstick guide tube at the oil pan.

3 Unscrew oil pan at the crankcase and remove.

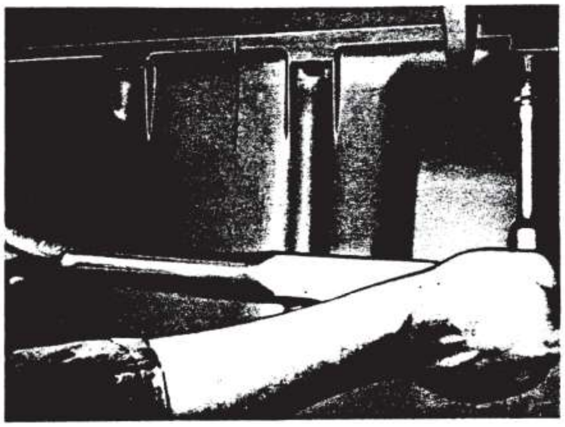
4 Wash oil pan.



Installation

1 Fit new gasket on oil pan.

2 Place oil pan on the crankcase and tighten securing bolts to 30 Nm (see tightening diagram).

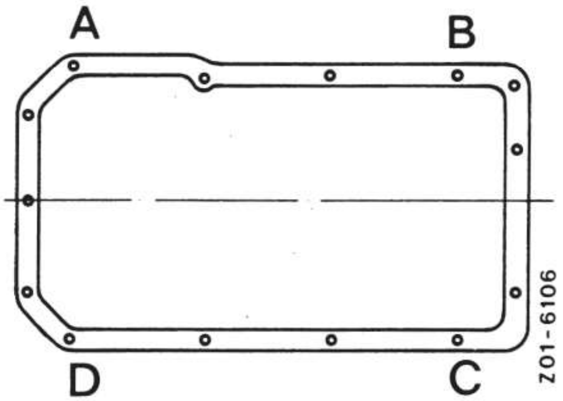


3 Tightening diagram, oil pan

a) Tighten corner bolts crosswise A–C and B–D to 30 Nm.

b) Tighten remaining bolts in their order on the periphery to 30 Nm (starting from the last corner bolt to be tightened).

c) Retighten corner bolts to 30 Nm.

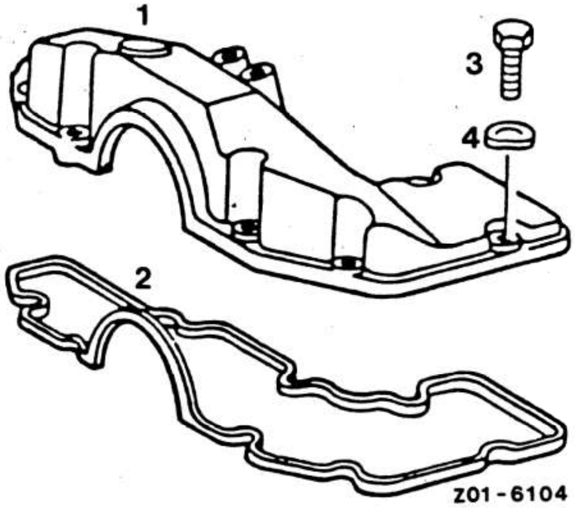


4 Secure oil filler tube and dipstick guide tube to the oil pan.

5 Fit oil drain plug and tighten to 80 Nm.

6 Fill with engine oil.

01 – 8000 Sealing Timing Case Cover



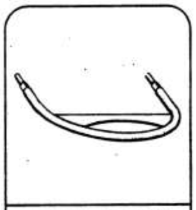
1 Timing case cover	Special tool 403 589 05 63 00
2 Gasket	renew, see note
3 Bolt	25 Nm
4 Spring washer	

Note: Remove grease at both corners between the crankcase mating surface and gasket for the injection pump flange and seal with silicon sealing compound (Point 4).

Seal mating surface on the right and left between the crankcase and timing case with silicon sealing compound (Point 5).

Use hand gun 000 589 01 25 00.

Special tools

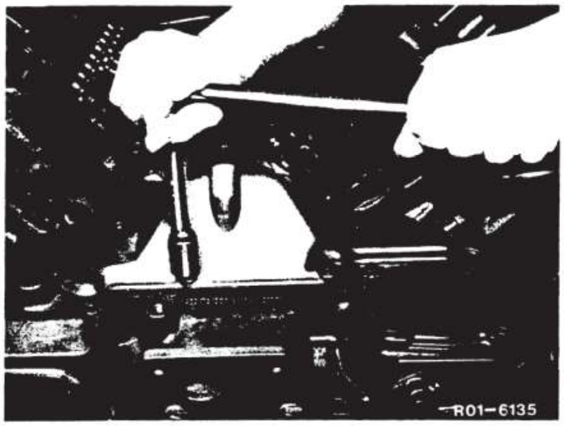

403 589 05 63 00

000 589 01 25 00

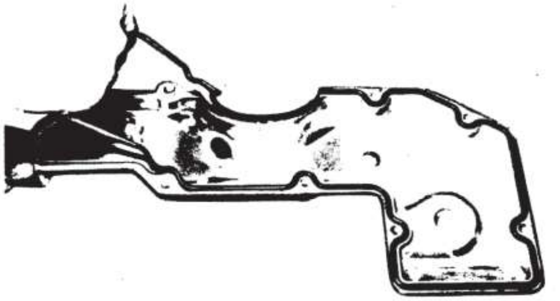
Sealing

1 Unscrew fuel filter at the timing case cover and remove manifold for turbocharger.

2 Unscrew timing case cover, detach and remove sealing ring.



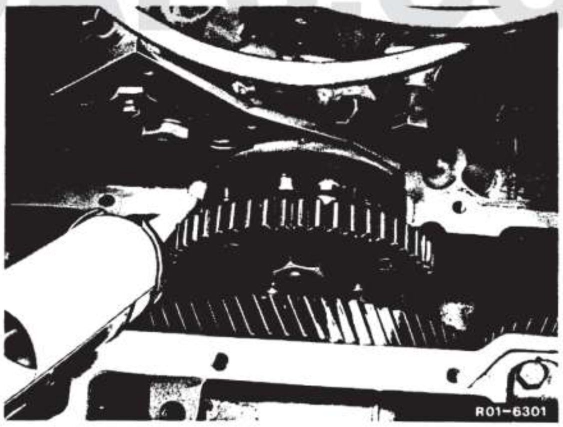
3 Carefully fit new sealing ring in the timing case cover.



R01–6136

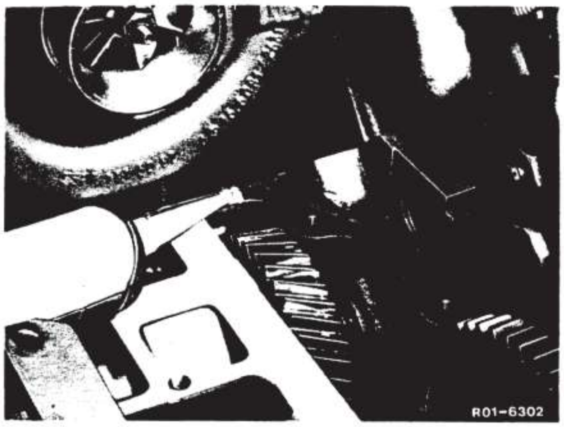
4 Remove grease at both corners between the crankcase mating surface and injection pump flange gasket and seal with silicon sealing compound.

Hand gun 000 589 01 25 00



5 Seal mating surface on the right and left between the crankcase and timing case with silicon sealing compound.

Hand gun 000 589 01 25 00



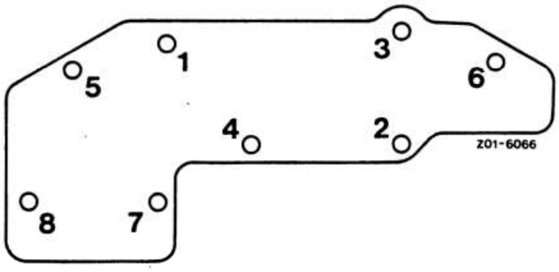
6 Fit timing case cover and fix in position with special tool.

Installation fixture 403 589 05 63 00

7 Fit securing bolts and tighten timing case cover in the sequence shown in the bolt tightening diagram to 25 Nm.

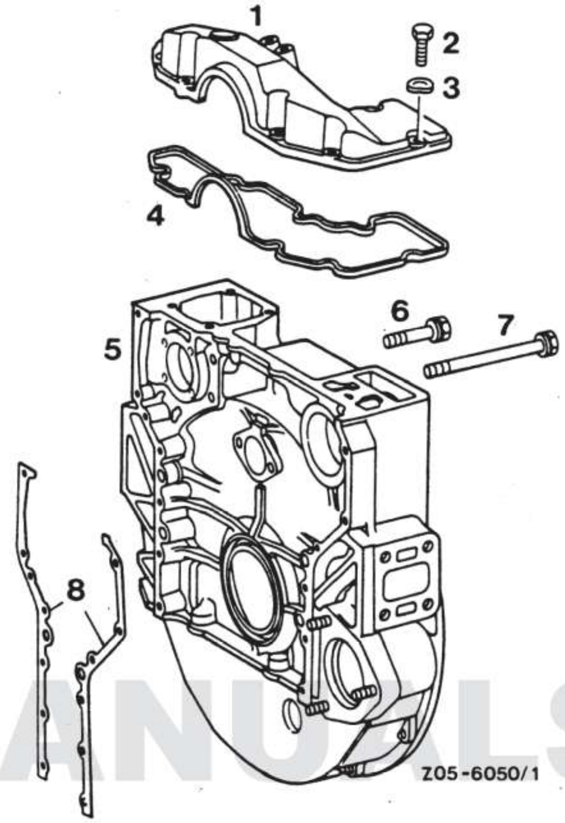
8 Fit fuel filter on timing case cover and tighten to 80 Nm.

9 Install manifold for turbocharger.



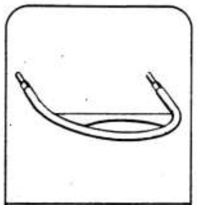
01 – 8205 Removal and Installation of Timing Case

Engine removed
Flywheel removed

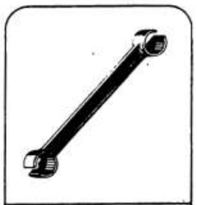


1	Timing case cover	Special tool 403 589 05 63 00
2	Bolt	25 Nm
3	Spring washer	
4	Gasket	renew
5	Timing case	
6	Bolt M 12 x 1.5	100 Nm
7	Bolt M 10	60 Nm
8	Gasket	renew, cut to length

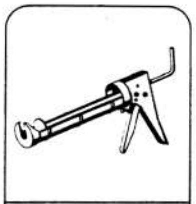
Special tools



403 589 05 63 00

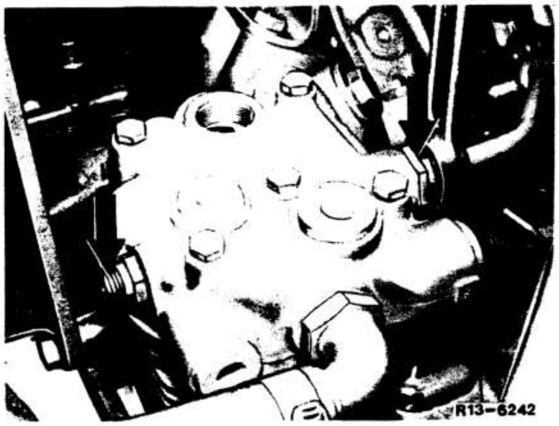


000 589 07 03 00



000 589 01 25 00

Removal

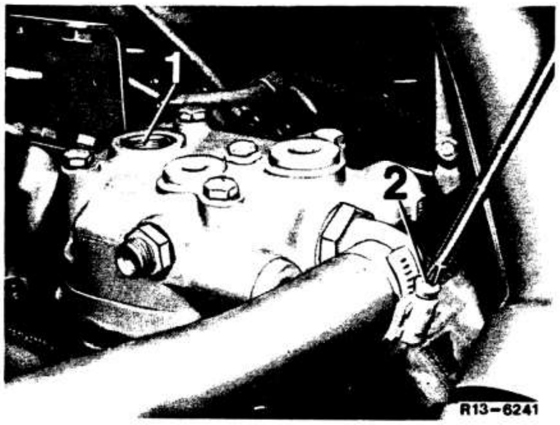


1 Detach engine brake cylinder at exhaust manifold.

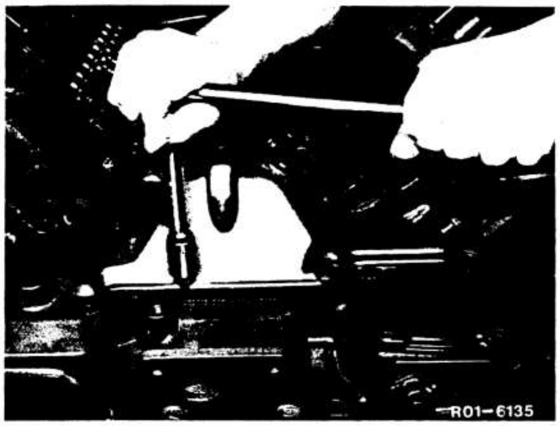
2 Remove oil delivery and return line at the power steering pump.

3 Unscrew coolant supply and return line (arrow) with special tool at the compressor.

Special wrench 000 589 07 03 00



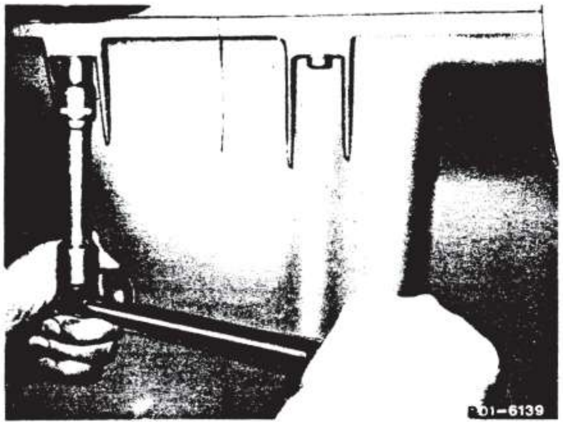
4 Remove air intake hose and compressed air line (1) at compressor.



5 Unscrew fuel filter at the timing case cover and remove.

6 Unscrew timing case cover.

7 Slacken bolts holding the oil pan and lower oil pan.

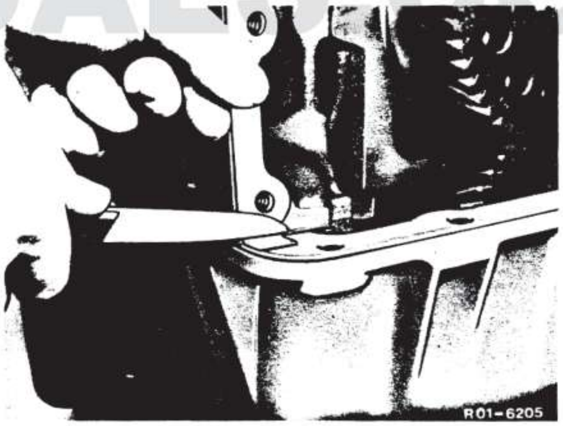

R01-6139

8 Slacken bolts holding the timing case and remove timing case.

R01-6143

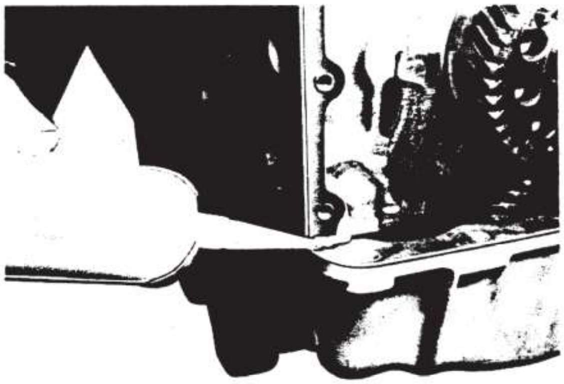
Installation

1 Place new gasket over the guide pins on the timing case and cut to length.


R01-6205

2 Seal point of intersection between timing case gasket and oil pan gasket with silicon sealing compound.

Hand gun 000 589 01 25 00


R01-6207

3 Fit timing case over the guide pins. Insert securing bolts and tighten as follows.

M 10 60 Nm.

M 12 100 Nm.

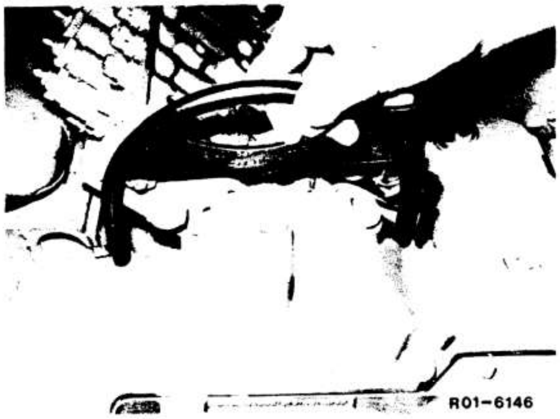
4 Tighten oil pan to 30 Nm.

5 Remove grease at both corners between crankcase mating surface and gasket for injection pump flange and seal with silicon sealing compound. Seal mating surface on right and left between crankcase and timing case with silicon sealing compound.

Hand gun 000 589 01 25 00

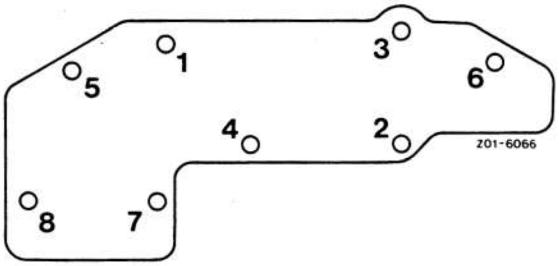
6 Fit timing case cover with new sealing ring and fix in position with special tool.

Installation fixture 403 589 05 63 00



7 Tighten timing case cover in the sequence shown in the bolt tightening diagram to 25 Nm.

8 Fit fuel filter to timing case cover and tighten to 80 Nm.

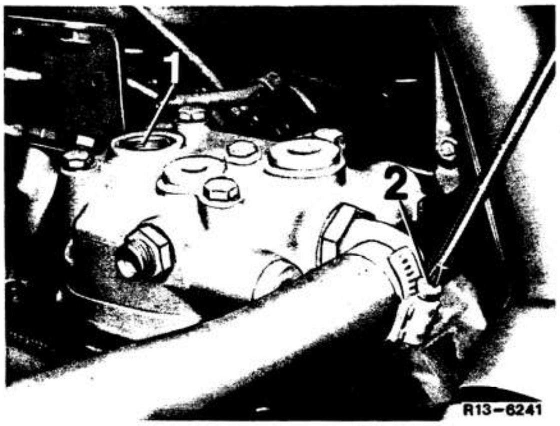


9 Connect air intake hose and compressed air line at compressor.

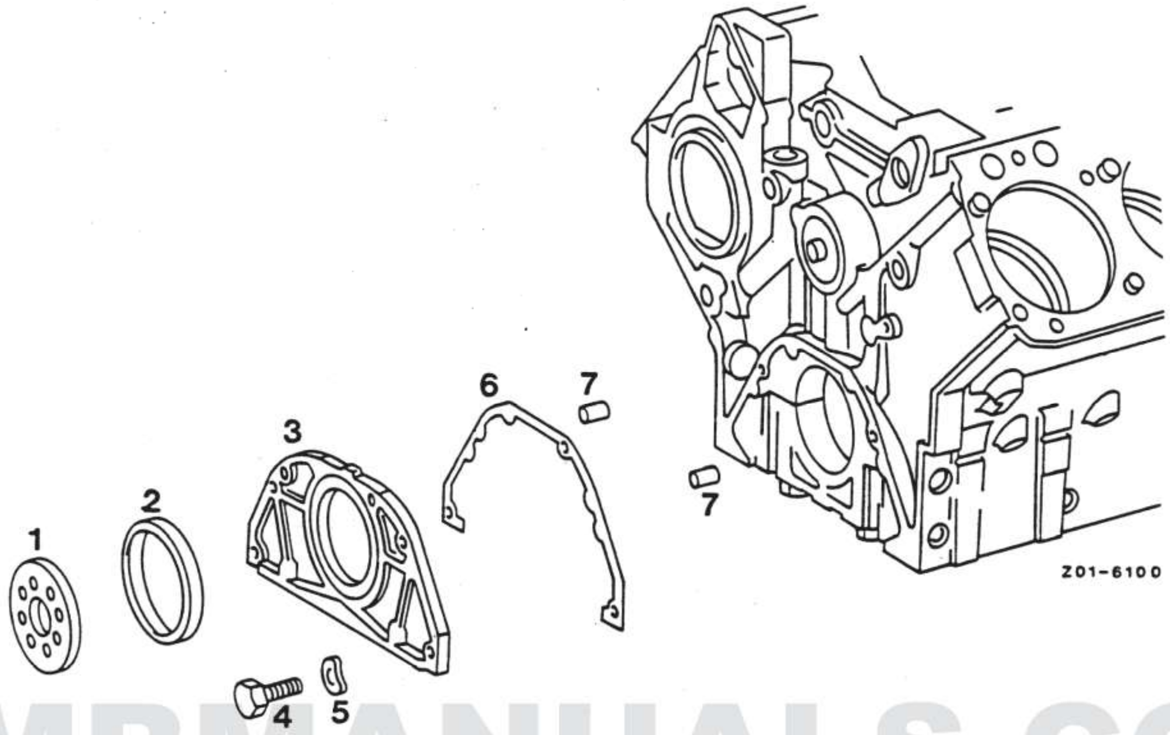
10 Attach engine brake cylinder to exhaust manifold and secure.

11 Connect coolant supply and return line (1) to compressor.

12 Connect oil delivery and return line at the power steering pump.



01 – 8810 Renewing Front Shaft Sealing Ring in Crankcase Cover

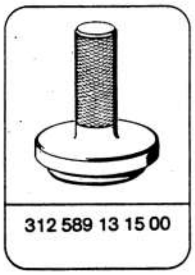


1 Splash ring	
2 Shaft sealing ring	renew, special tool 312 589 13 15 00
3 Crankcase cover	
4 Bolt	25 Nm
5 Spring washer	
6 Gasket	renew
7 Guide pin	

Tightening torques

	Nm
Pulley to hub	30
Pulley to vibration damper	30
Hub to crankshaft	200
Vibration damper to crankshaft	200
Oil pan to crankcase	30

Special tools

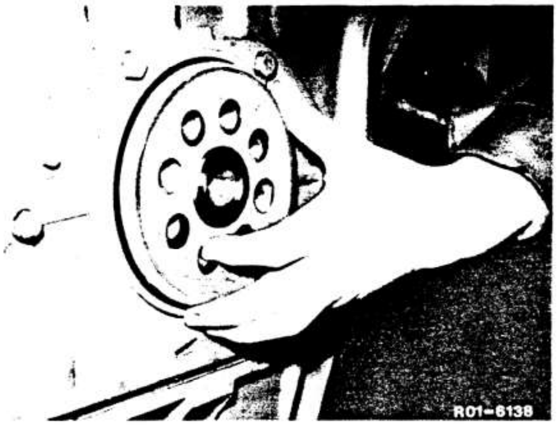

312 589 13 15 00

Renewing shaft sealing ring

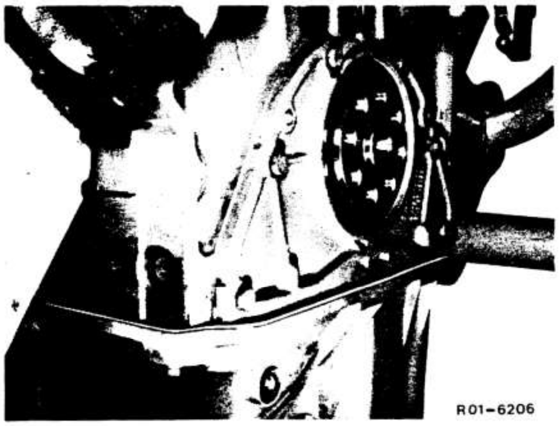
1 Remove fan with pulley.

2 Remove hub or vibration damper from the crankshaft.

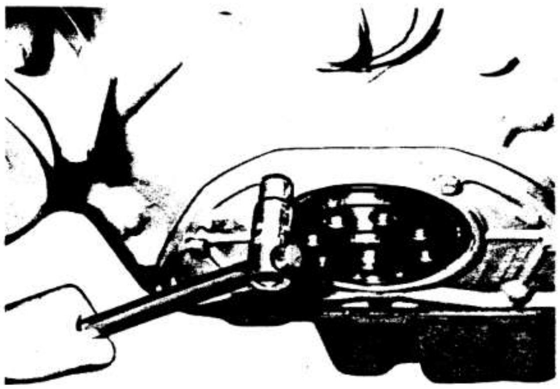
3 Remove splash ring.



4 Slacken bolts holding the oil pan and lower oil pan.



5 Unscrew cover with shaft sealing ring at the crankcase.

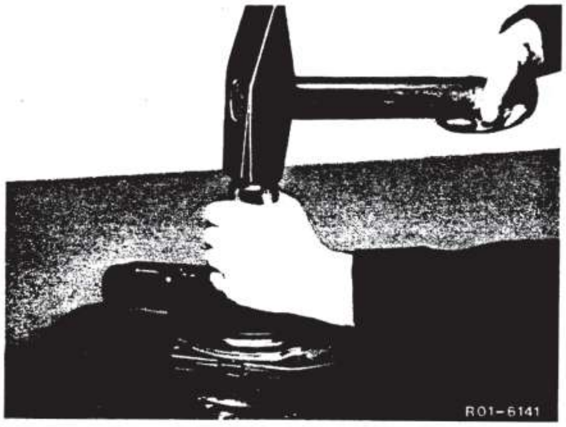


R01–6140

6 Using special tool, drive the shaft sealing ring out of the cover.

Note: Support cover when knocking out the shaft sealing ring.

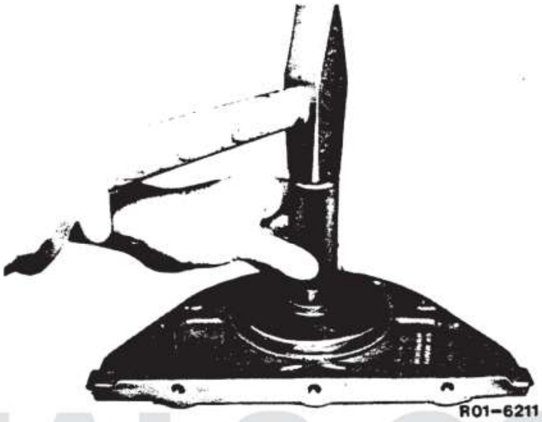
Drift 312 589 13 15 00



7 Place cover flat on an even surface and drive in shaft sealing ring until it is flush with the base surface.

8 Apply oil to bearing race on the crankshaft and to the fabric sealing ring.

Drift 312 589 13 15 00



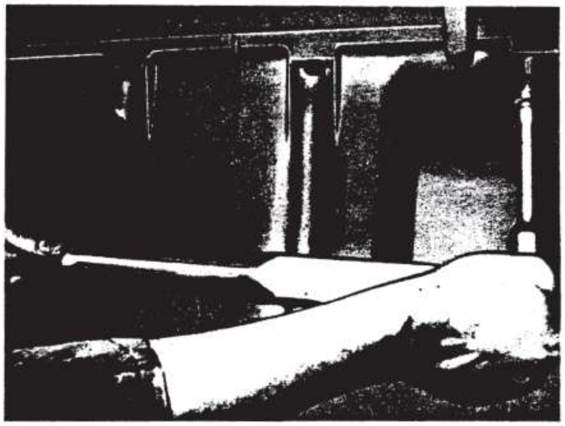
9 Fit new gasket over the guide pins on the crankcase.

10 Mount cover with shaft sealing ring and tighten to 25 Nm.

11 With the aid of a feeler gauge, check that the sealing ring is correctly fitted on the crankshaft.

12 Tighten oil pan securing bolts to 30 Nm.

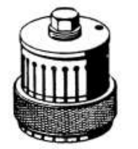
13 Mount splash plate.

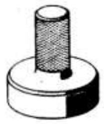


01 – 8825 Renewing Bearing Ring on Crankshaft

Cover with shaft sealing ring removed

Special tools


403 589 01 33 00

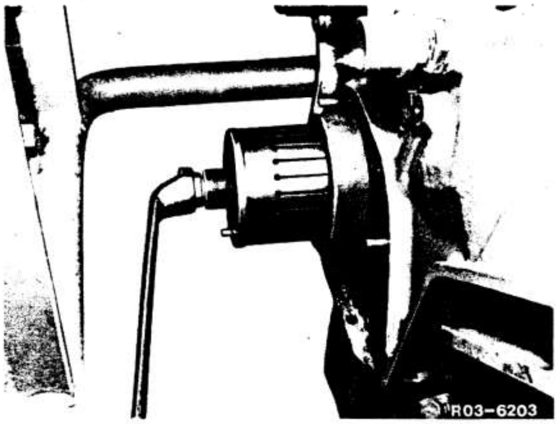

403 589 06 15 00

Renewing bearing ring

1 Place special tool over the bearing ring on the crankshaft and press on clamping sleeve.

2 Remove bearing ring.

Puller 403 589 01 33 00

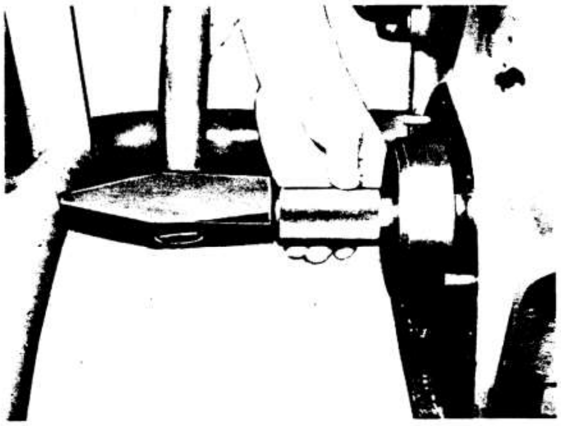


3 Heat new bearing ring on a hot plate to approx. 200° C.

4 Insert bearing ring in special tool and drive onto crankshaft.

5 Coat the running surface for the shaft sealing ring with engine oil.

Drift 403 589 06 15 00



01 – 9112 Removing Corrosion on Machined Surface of the Crankcase

Cylinder heads removed

Reworking machined surface

Note: The pistons and cylinder liners must be removed if the corrosion points are in the immediate vicinity of the cylinder liner flange.

1 Close off cylinder bores and oil ducts.

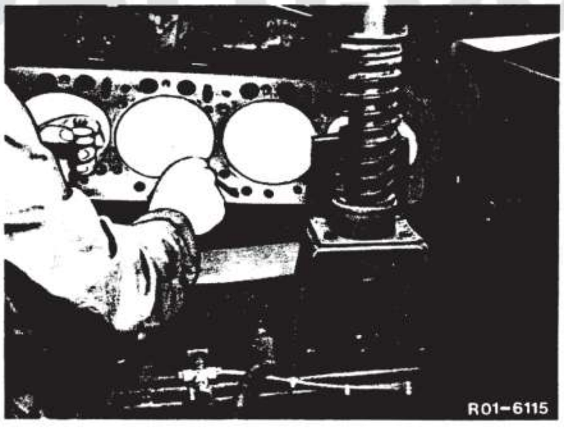
2 Grind the points to be treated until they are metal bright.

R01–6113

3 Clean ground point of oil, grease and water residue with degreaser (from repair kit).

4 Using the relevant wooden spatula, remove both components (base and reactor) from the cans, weigh the same component parts on a balance and mix thoroughly.

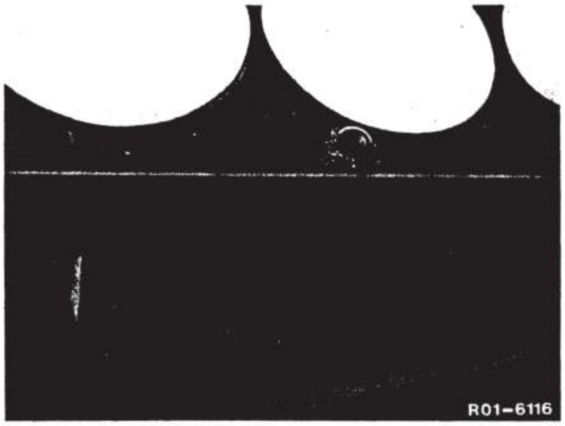
Note: Use red wooden spatula only for reactor and black for base.


R01–6115

5 With a hot air blower, heat the point to be sealed to a temperature of approx. 60–70° C.

6 Apply the binding metal compound with a wooden spatula to the cleaned point.

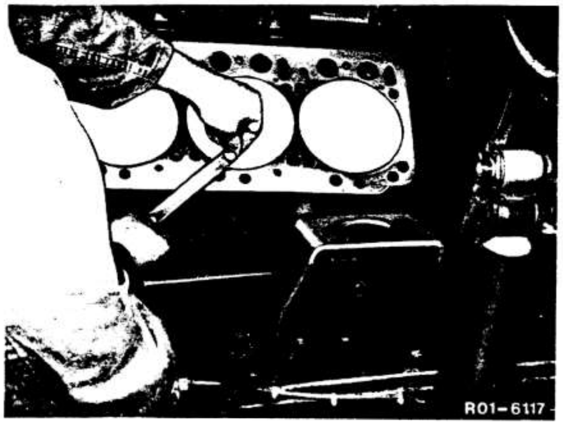
7 Heat applied compound with a heat lamp and allow to harden for a minimum of 4 hours at approx. 60° C.


R01–6116

8 File flat the appropriate points with a bastard file.

9 Clean mating surface and remove covers from the cylinder bores and oil ducts.

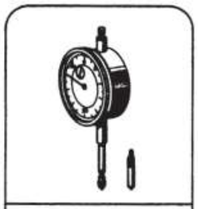
10 Assemble engine.



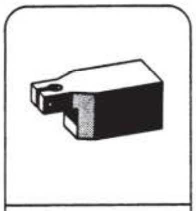
01 – 9304 Remachining Flange Seat in Crankcase

Shim rings	0.8 mm 1.0 mm 1.5 mm

Special tools



001 589 53 21 00



343 589 00 40 00

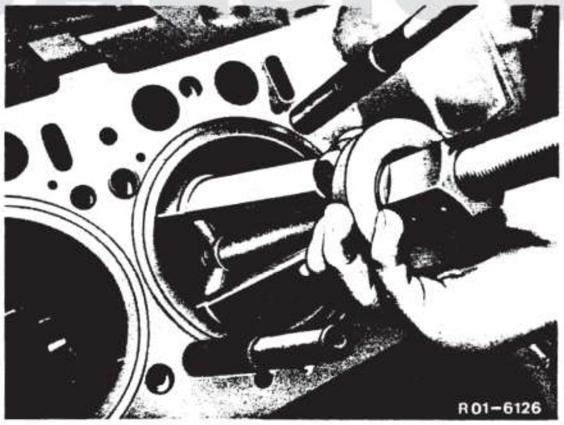
Workshop equipment

Liner flange seat machining unit

Remachining crankcase

1 Remove piston and cylinder liners.

2 Preparatory work
Place pieces of rubber foam (e.g. upholster foam 40 mm) in the liner bores and arrange as high as possible in the area to be machined such that crankshaft and bearing are protected from falling dirt and metal chips. Cover oil holes, particularly the adjacent cylinders, e.g. with a plastic film.



3 Thoroughly clean the mating surface of the crankcase and bore for the cylinder liners.

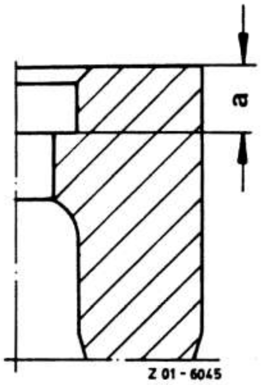
4 Determine the shoulder depth:
Average dimension liner flange (measure at 4 points, max. difference of 4 measured points for each cylinder liner 0.02 mm).

+ Shim thickness
– Required liner projection
= Shoulder depth

Example:
(0.8 mm thick shim)

Average size of liner flange	10.05
+ required thickness of shim	0.80
	10.85
– required liner projection	0.09
= shoulder depth	10.76

a = shoulder depth

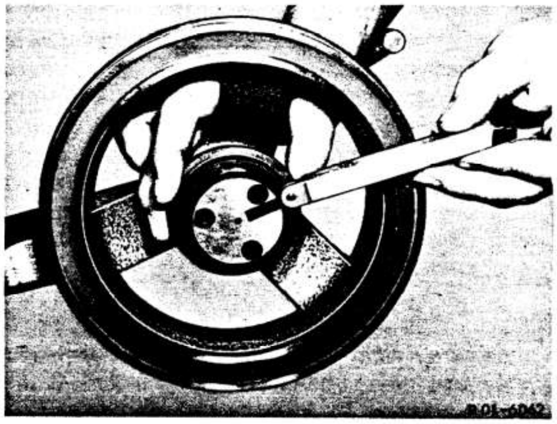


Z 01 - 6045

5 Clamp cutting tool in position. The machining unit and the tool must be cleaned (with compressed air) before inserting the cutting tool. Lightly oil cutting tool and thread insert.

R03–6210

Pull up the quick-action setting ring to insert the cutting tool in the holder. The cutting tool must be inserted such that the centering roller comes to rest on the side marked with "R" on the cutting tool holder and the feed thread on the cutting tool points away from the quick-action setting ring.



R 01-6042

6 Connect mains plug. Place unit on the cylinder bore to be machined and switch on electric magnet.

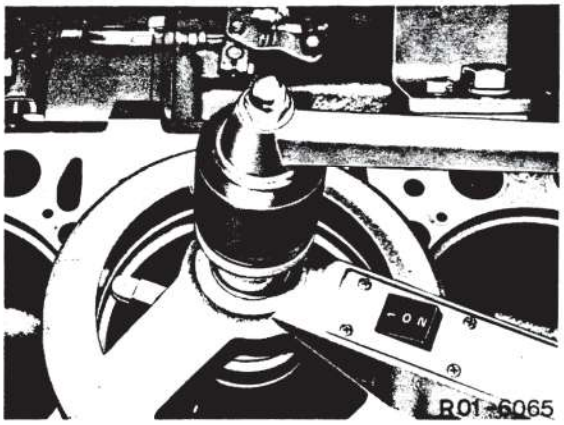
Note 1: When using the machining unit for the first time, the blue protective coating on the magnet surface must be removed with thinners.

Note 2: Align the unit such that the distance from the edge of the cylinder bore to the edge of the magnetic ring is uniform about the circumference (center).

R03–6211

7 Pull up quick-action setting ring with 2 fingers of both hands. Hold raised quick-action setting ring with 2 fingers of one hand and, with the free hand, slide through the cutting tool until the centering roller rests on the side wall of the flange.

Note: The correct height of the centering roller is set with the feed nut.

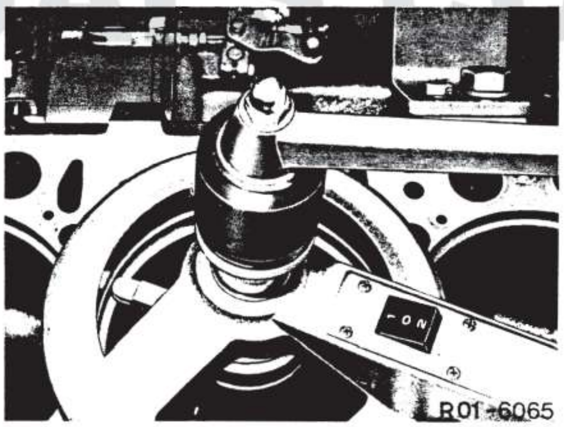


R01-6065

8 By lightly pressing the toggle switch, set to position 2 in horizontal mid-position. In this way, residual magnetism remains in the magnetic ring which holds the unit on the sealing surface.

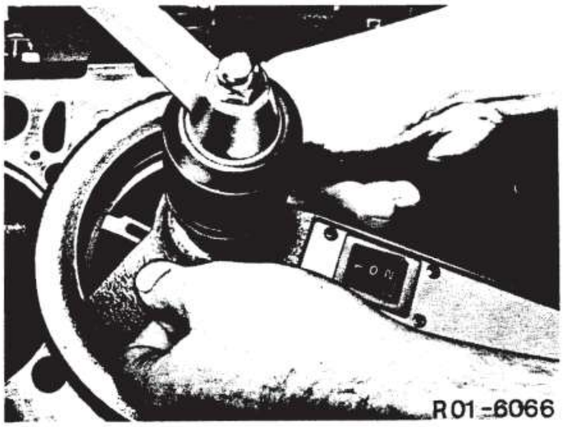
9 Turn drive crank in clockwise direction and check **whether the centering roller runs over the entire circumference** and the unit (in mid-position of the toggle switch) is not shifted. If the unit is shifted, turn the drive crank in clockwise direction while firmly holding the feed ring with 2 fingers. If the centering roller loses contact with the edge of the flange, while firmly holding the feed ring, turn the drive crank in counterclockwise direction until the roller once again has contact over the entire circumference.

Note: When correctly centered, the centering roller must have uniform contact over the entire circumference and the unit must not be displaced when in switch position "0".



R01-6065

10 After precise centering, press toggle switch to setting 1. Raise quick-action setting ring and slide through the cutting tool until the cutting edge is located above the lining flange seat to be machined without coming in contact with the side wall.

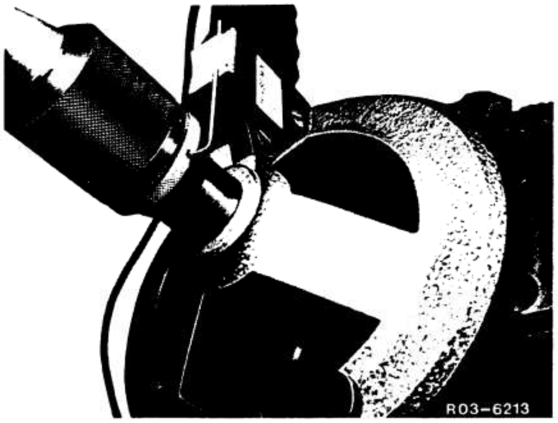


R01-6066

11 Carefully turn drive crank and feed nut uniformly in clockwise direction until the cutting tool makes contact with the lining flange seat.

12 Lift quick-action setting ring and slide back the cutting tool into the free area to just before the flange seat.

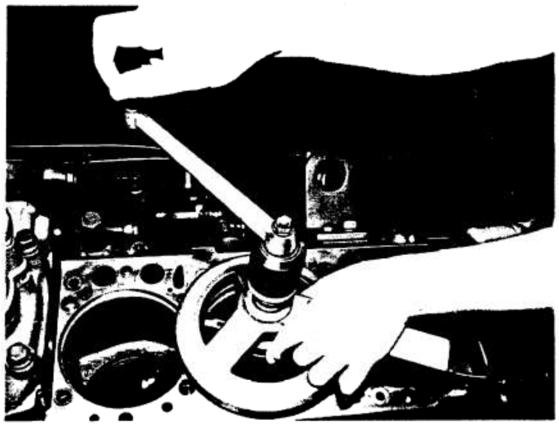
13 Release socket head cap screw for vernier adjustment, set vernier ring to "0" and retighten socket head cap screw.



14 Set the required material removal 0.05 mm with the feed nut.

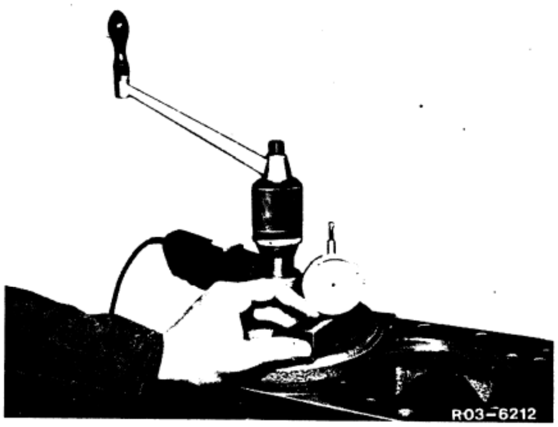
Note: 1 line graduation on the vernier = 0.01 mm.

15 Turn the drive crank uniformly in clockwise direction while at the same time firmly holding the feed ring with the other hand.



Note 1: As a check, measure the shoulder depth from the flat surface of the turning device after cutting (0.05 mm).

Note 2: The cutting tool is ground such that the required diameter cannot be exceeded. This means the end face of the cutting tool runs on the diameter of the cylinder bore. If difficulties are encountered, immediately release the feed ring and turn the drive crank several times.



The cutting tool must be reground only as shown in the drawing supplied with the machining unit.

Caution
The feed nut must on no account move when turning the drive crank otherwise the depth setting of the cutting tool will be altered. If necessary, the screw in the feed nut must be retightened.

16 Lift quick-action setting ring with two fingers and slide back cutting tool to its initial position; apply feed with the feed nut 0.05 mm and repeat turning procedure until the required dimension is achieved.

Note 1: Approx. 0.3 mm before reaching the determined shoulder depth, remove the device and measure the shoulder depth with a dial gauge. This measurement should be repeated towards the end of turning work to ensure that the required final dimension is reached. After each measurement, the device must be centered as described in Point 1.

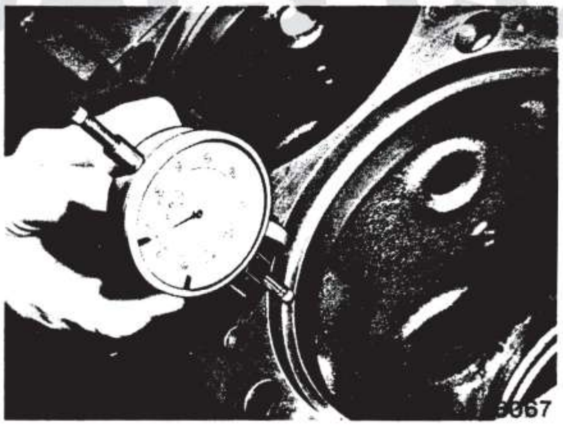
Dial gauge	001 589 53 21 00
Dial gauge holder	343 589 00 40 00

Note 2: To ensure the cutting tool is not damaged, it should not be returned using the feed.

17 Switch off magnet, remove machining device.

18 Measure shoulder depth. The maximum difference of the 4 measuring points must not exceed 0.02 mm.

Dial gauge	001 589 53 21 00
Dial gauge holder	343 589 00 40 00

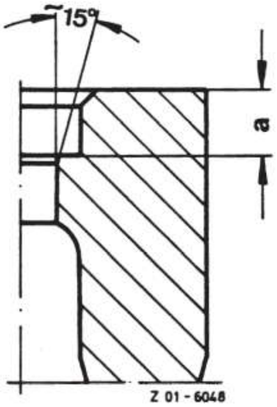


19 Chamfer edge of upper lining fit by approx. 15° with a flat scraper.

a = Shoulder depth

20 Remove metal chips in crankcase (e.g. magnet) and clean with petroleum. Remove dirty pieces of foam by pulling upwards. Clean once again with petroleum.

21 Before starting, crank the engine with the starter until oil pressure is indicated.

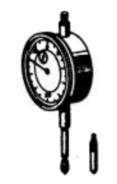


01 – 9314 Measuring Projection of Cylinder Liner

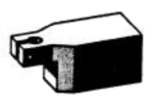
Data

Liner projection from upper edge of crankcase to outside diameter	0.03–0.09

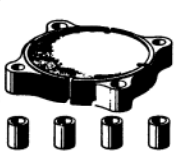
Special tools



001 589 53 21 00



343 589 00 40 00

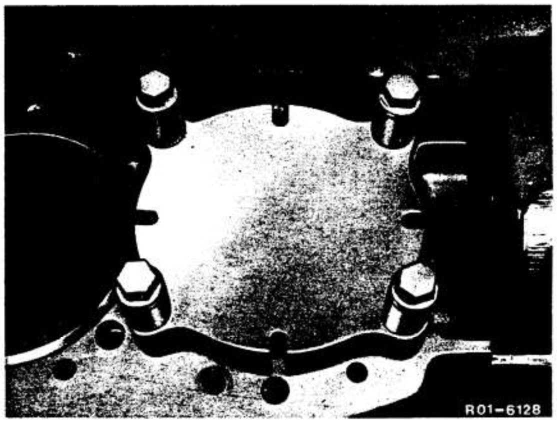


402 589 00 21 00

1 Remove cylinder heads and clean upper edge of cylinder liners.

2 Place measuring plate on the cylinder liner. Tighten short cylinder head bolts with spacer sleeves to 50 Nm.

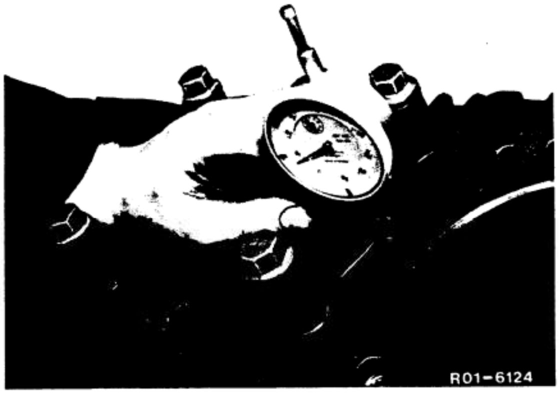
Measuring plate 402 589 00 21 00



3 Mount dial gauge holder on the measuring plate and fit the dial gauge with extension such that the plunger is preloaded on the crankcase. Secure dial gauge.

Set scale of dial gauge to "0" and measure the projection of the cylinder liner at 4 points (in forward direction and offset by 90°).

Dial gauge	001 589 53 21 00
Measuring plate	402 589 00 21 00
Dial gauge holder	343 589 00 40 00



Note: In each measuring position, reset the dial gauge on the mating surface (zero setting). The maximum difference of the four measuring points on each cylinder liner is 0.02 mm. The cylinder heads of the adjacent cylinders must be removed in order to measure the projection of the cylinder liner. Use specification sheet 800.99.452.00 A to enter the projection values for the cylinder liners.

Dial gauge	001 589 53 21 00
Measuring plate	402 589 00 21 00
Dial gauge holder	343 589 00 40 00

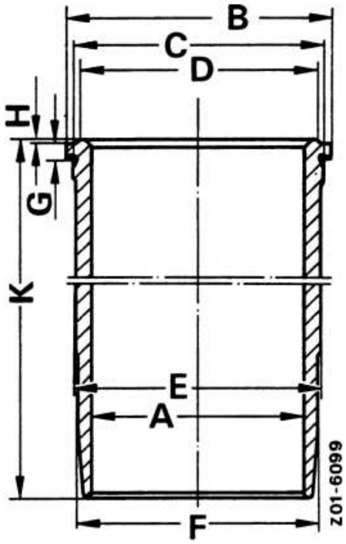
R01–6124

01 – 9324 Removal, Installation and Sealing of Cylinder Liner

Data

Inside diameter of cylinder liner dimension "A"[1]

Code letter	Engine 441 LA 442 A, LA 443 LA 443 A[3], LA[3]	Engine 441 442 443
"B"	127.995 127.990	129.995 129.990
"C"	128.000 127.995	130.000 129.995
"D"	128.005 128.000	130.005 130.000
"E"	128.010 128.005	130.010 130.005



Flange outside diameter, dimension "B"	153.757 153.657
Upper fit diameter, dimension "C"	145.800 145.778
Diameter for cylinder head gasket, dimension "D"	142.0 141.8
Outside diameter, dimension "E"	145.0 144.7
Outside diameter, dimension "F"	144.475[2] 144.451
Flange thickness, dimension "G"	10.07 10.05
Flange recess, dimension "H"	1.10 1.00
Total length, dimension "K"	253 ± 0.5

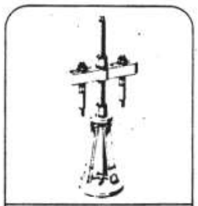
[1] Wear in the liner at top reversal point of first piston ring max. 0.08

[2] Out-of-round at lower fit

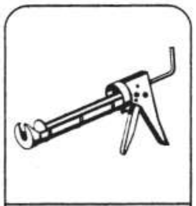
outside	max. 0.06
inside (liner installed)	max. 0.04

[3] Industrial engine

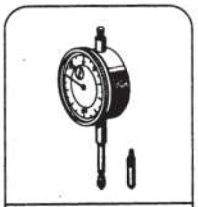
Special tools



403 589 00 33 00



000 589 01 25 00



001 589 53 21 00

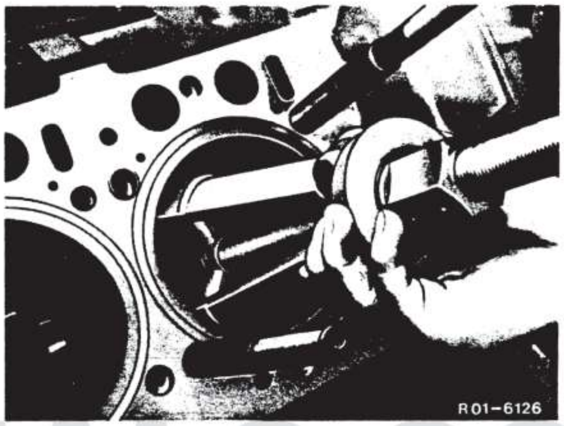
Removal

1 Mark cylinder liners with respect to the crankcase.

Note: Before using the liner extractor/installer 403 589 00 33 00, check the spacer sleeve and, if necessar shorten to a size of 175 mm.

2 Insert stud bolts in opposing threaded holes for cylinder head bolts.

Extractor/installer 403 589 00 33 00



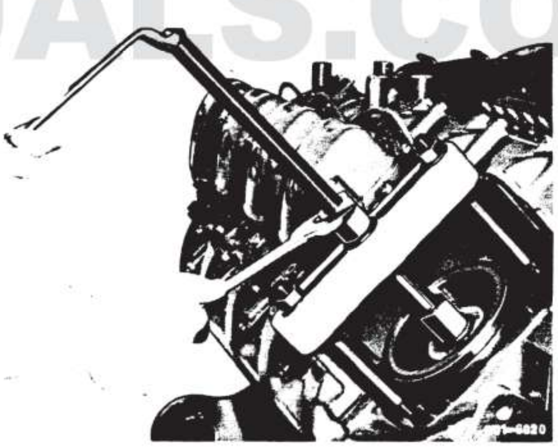
3 Insert special tool in the cylinder liner.

4 With the aid of the spindle turn apart the arms of the puller to the inside diameter of the cylinder liner.

5 Place countersupport on the stud bolts and secure.

6 Withdraw the cylinder liner by turning the hexagon nut while holding the spindle with a ring wrench.

Extractor/installer 403 589 00 33 00



7 Turn together the arms of the puller by turning the spindle. Unscrew countersupport and remove together with puller.

8 Remove cylinder liner from the crankcase.

9 Remove O-rings from the crankcase and cylinder liner.

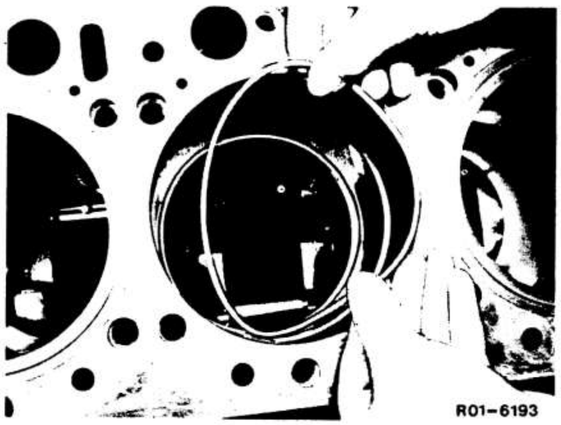
10 Clean cylinder liners and bores in the crankcase. In particular the lining flange and the lining contact surface in the crankcase as well as the grooves for the lower O-rings must be thoroughly cleaned.

R01-6183

Installation and Sealing

1 Insert new sealing rings (O-rings) for the lower cylinder liner seal in a dry condition in the crankcase.

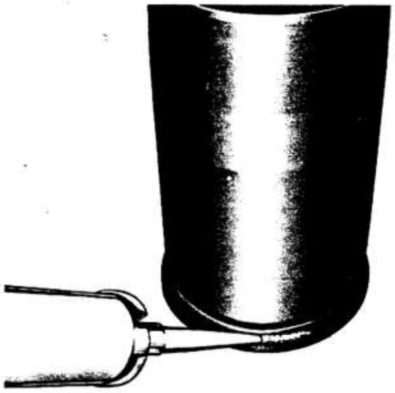
2 Insert new sealing rings for the upper cylinder liner seal in the cleaned recesses of the cylinder liner.


R01-6193

3 Apply sealing compound in a slug of approx. 2–3 mm diameter ahead of the sealing ring on the liner flange.

Note: Sealing compound must be processed only when in a pasty condition. After opening, the storage time of the cartridge is approx. 4 weeks.

Hand gun 000 589 01 25 00


R01-6295

4 Lightly coat cylinder liner with ATE installation grease at the lower fit surfaces and slip angles.

5 Insert cylinder liner, turned by 90° with respect to the old installation position in the crankcase.

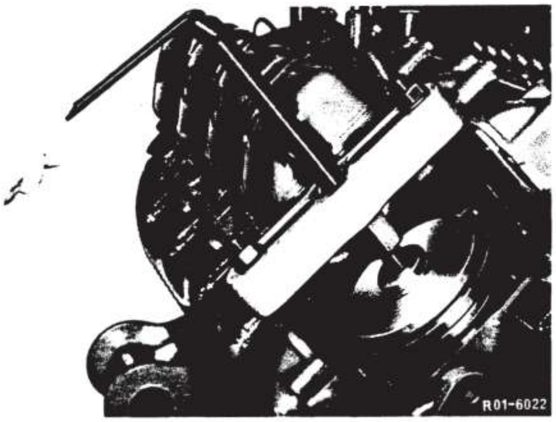
R01-6192

6 Screw in stud bolts of the extractor/installer in opposing threaded holes for the cylinder head bolts.

7 Place pressure plate on liner.

8 Place installer (spindle with countersupport) on stud bolts and secure.

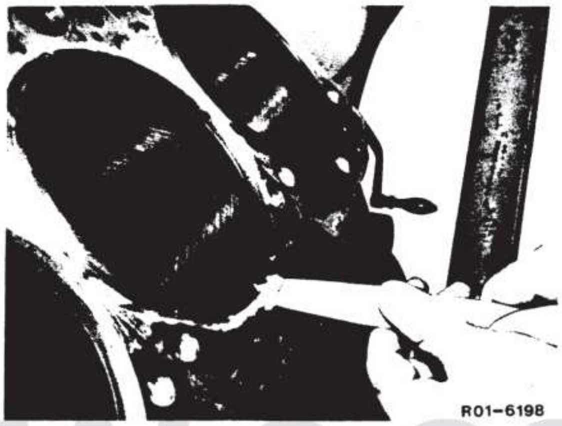
Extractor/installer 403 589 00 33 00



9 By turning the spindle, maintain a load on the cylinder liner of 120 Nm for 5 minutes.

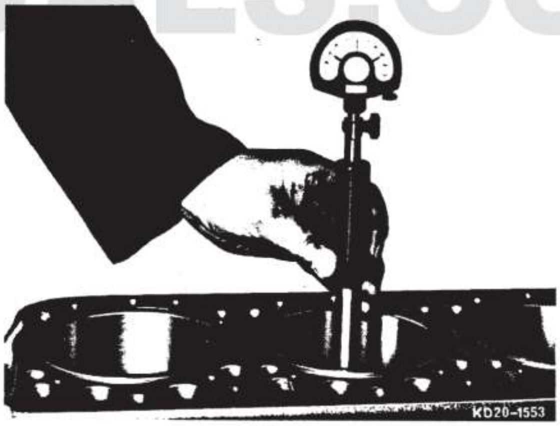
10 Using a plastic spatula, carefully remove the sealing compound which is pressed out between the crankcase and cylinder liner when load is applied on the cylinder liner.

11 Remove installer from crankcase.



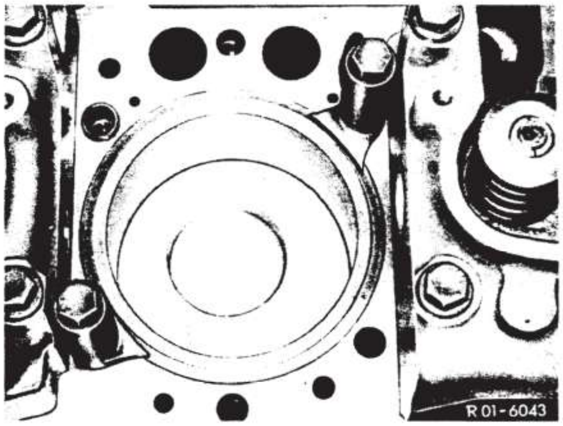
12 Measure inside diameter of cylinder liner in the area of the lower fit surface with an internal measuring instrument at three points, each offset by 60°.

Note: The fit of the lower sealing rings must be checked if the out-of-round is measured to be greater than 0.04 mm.



13 Hold the cylinder liner under preload (approx. 30 Nm) with two self-made sleeves to prevent them becoming loose during installation of the pistons.

Caution: If used pistons are reinstalled during the repair work, the first piston ring must be renewed in the case of naturally aspirated engines and the second piston ring in the case of turbocharged engines.



01 – 9751 Removal and Installation of Oil Separator

Data	
Control range of oil separator	+ 10 to – 100 mm water column

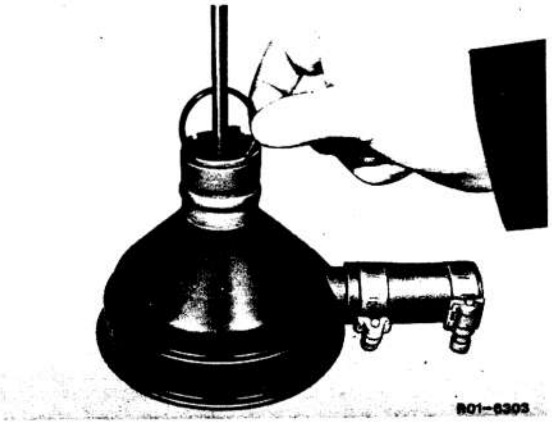
Tightening torques	Nm
Oil separator to crankcase	8

Removal

1 Release securing clip and detach hose at oil separator.

2 Unscrew oil separator at crankcase and remove.

Installation



1 Insert O-ring in the oil separator.

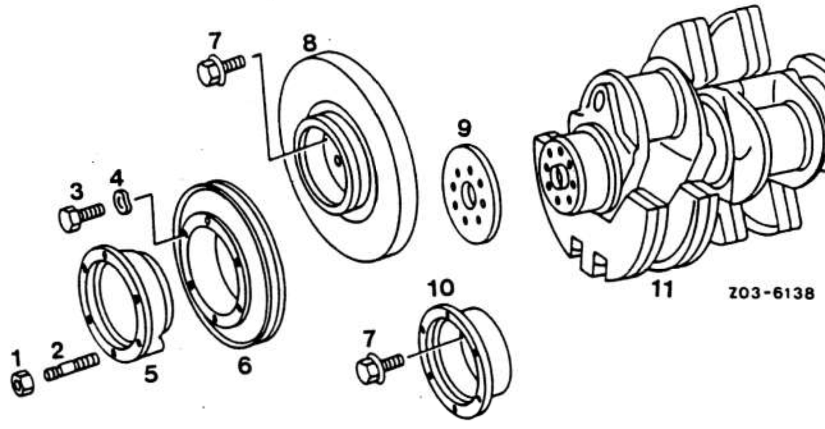
2 Place oil separator over the connection coupling the crankcase.

Note: Particular care must be taken during maintenance and repair work to ensure that the oil separator is not damaged. Slight damage, such as dented cover, can result in failure of the oil separator. A damaged oil separator must always be renewed.

3 Secure oil separator with 8 Nm to the crankcase.

4 Fit hose to oil separator and tighten hose clip.

03 – 1600 Removal and Installation of Vibration Damper or Hub



1	Nut	25 Nm
2	Setscrew	
3	Bolt	25 Nm
4	Spring washer	
5	Intermediate piece	
6	Pulley	
7	Bolt	200 Nm
8	Vibration damper	
9	Splash ring	
10	Hub	
11	Crankshaft	

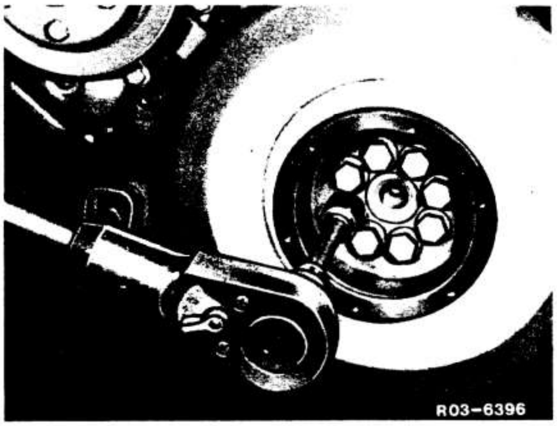
Removal

1 Remove V-belt.

2 Remove fan together with intermediate piece and pulley.

3 Unscrew vibration damper or hub and remove.

4 Remove splash ring.



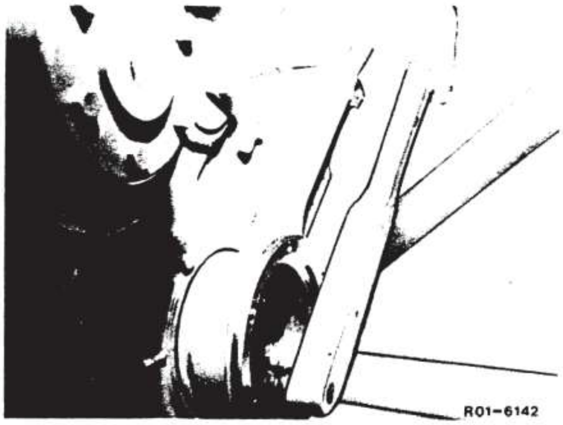
Installation

1 Fit splash ring.

2 Mount vibration damper or hub and tighten to 200 Nm.

3 Mount fan together with intermediate piece and pulley.

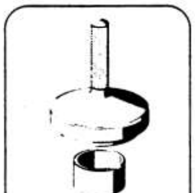
4 Fit V-belt and tension.



03 – 3062 Renewing Shaft Sealing Ring in Timing Case

Engine removed
Flywheel removed

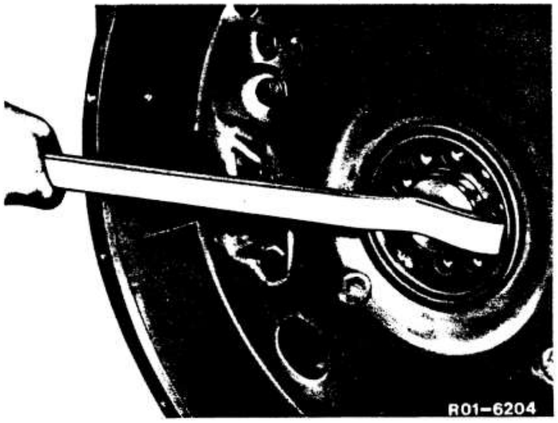
Special tool



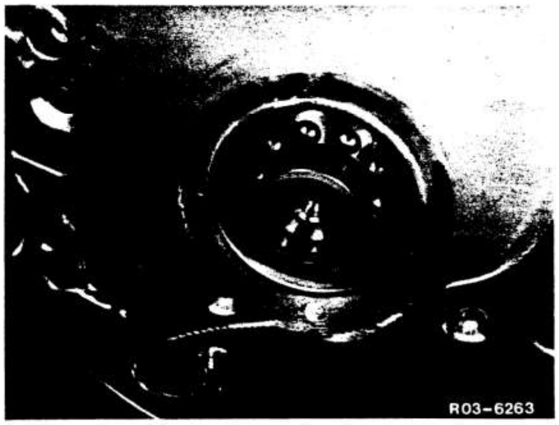
403 589 04 15 00

Renewing shaft sealing ring

1 With the aid of a crowbar, lever out the shaft sealing ring from the timing case.



2 Place spacer sleeve from special tool 403 589 04 15 00 over the crankshaft.



3 Place shaft sealing ring on special tool.

Drift 403 589 04 15 00

R03–6262

4 With the special tool, drive shaft sealing ring into the timing case.

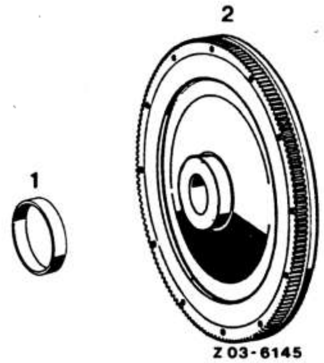
5 Oil the reverse rotating ring on the flywheel.

Drift 403 589 04 15 00

R03–6261

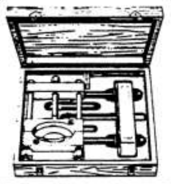
03 – 3203 Renewing Bearing Ring on Flywheel

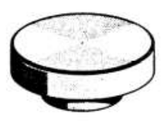
Flywheel removed

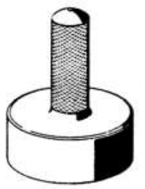


1 Bearing ring	Special tool 000 589 45 33 00, 312 589 00 15 00, 403 589 03 15 00
2 Flywheel	

Special tools


000 589 45 33 00

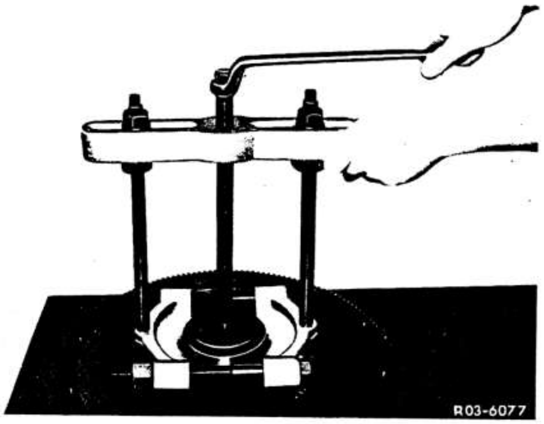

312 589 00 15 00


403 589 03 15 00

Renewing bearing ring

1 Remove bearing ring from flywheel with puller and pressure piece.

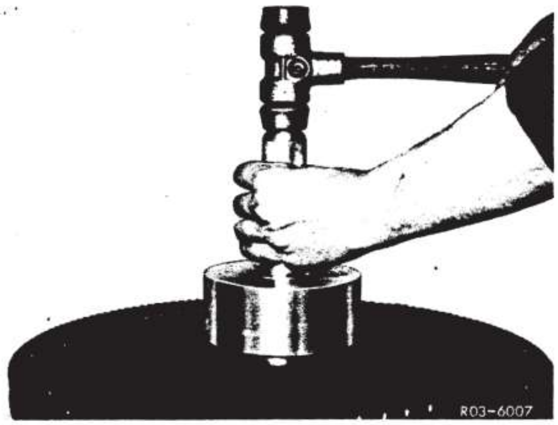
Puller	000 589 45 33 00
Pressure piece	312 589 00 15 00



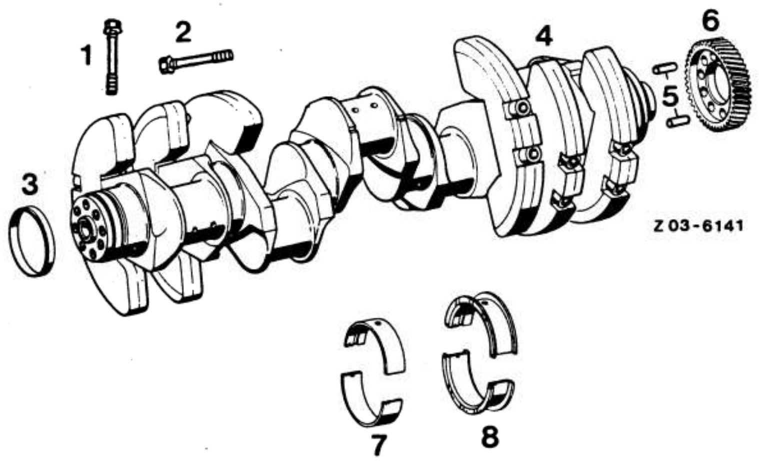
2 Insert new bearing ring (the rounded edge facing towards the special tool) in the special tool and heat on a hotplate to a maximum temperature of 200° C.

3 Fit bearing ring on the flywheel.

Drift 403 589 03 15 00



03 – 4352 Removal, Mounting in Bearings and Installation of Crankshaft



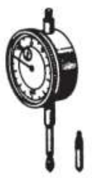
1 Crankshaft bearing cap bolt (vertical)	tighten crankshaft bearing cap in 4 stages (vertical bolts) 1st. stage 100 Nm. 2nd. stage 200 Nm. 3rd. stage 350 to 380 Nm 4th. stage 90° to 100° tightening angle **Elongation:** can be reused up to max. shank length 156 mm
2 Crankshaft bearing cap bolt (side)	80 Nm
3 Bearing ring	
4 Crankshaft	Special tool 403 589 02 63 00
5 Straight pin	
6 Crankshaft gear	
7 Bearing shells main bearings	
8 Bearing shells thrust bearing	

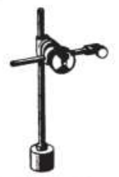
Data

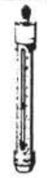
Allowances	Crankshaft bearing journal⌀	Crankshaft bearing⌀ when installed	Width of thrust bearing
Standard	104.000 103.980	104.112 104.066	37.81 37.74
Oversize allowance 0.1	103.900 103.880	104.012 103.966	
Oversize allowance 0.25	103.750 103.730	103.862 103.816	38.31 38.24
Oversize allowance 0.50	103.500 103.480	103.612 103.566	
Oversize allowance 0.75	103.250 103.230	103.362 103.316	38.31 38.74
Oversize allowance 1.00	103.000 102.980	103.112 103.066	

Max. out-of-round of bearing journals	0.02
Basic bore ∅ for crankshaft in crankcase	$\frac{111.040}{110.970}$
Aixal clearance of crankshaft (thrust bearing)	0.150–0.322
Radial clearance of crankshaft	0.087–0.153
Hardness of crankshaft journals over two thirds of the circumference	Rockwell hardness HRC 46

Special tools


001 589 53 21 00


363 589 02 21 00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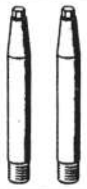

403 589 02 63 00

Removal

Vibration damper or hub removed. Pistons removed.

1 Move cover from front of crankcase.

R01–6140

2 Unscrew side bolts of crankshaft bearing caps.

3 Slacken vertical bolts and unscrew. Release crankshaft bearing caps with the bolts and remove.

Note: To avoid confusion, the crankshaft bearing caps and bearing shells of the crankshaft bearings must be marked corresponding to their installation sequence.

4 Screw in a guide pin at the front and rear ends of the crankshaft.

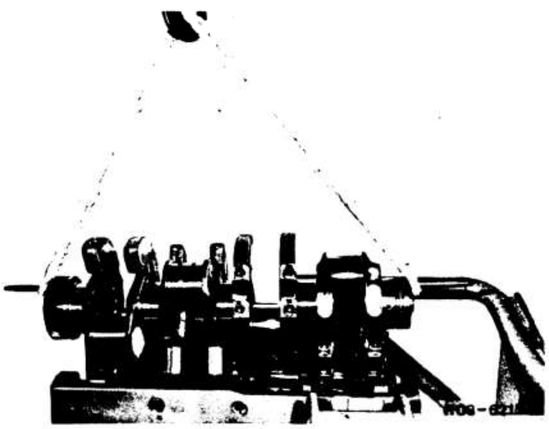
R03

5 Attach a hemp rope to the guide pins and, with the aid of lifting gear, lift the crankshaft out of the crankcase.

6 Remove bearing shell halves from the crankcase.

7 Check parts for damage and wear.

Guide pin 403 589 02 63 00



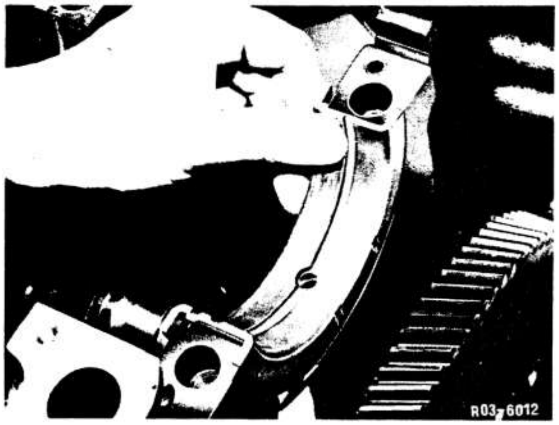
Note: Irrespective of the repair stage, the bearing shells for the crankshafts are supplied ready to be installed ex factory. The bearings therefore require no reworking whatsoever. An oversize thrust bearing is supplied for repair purposes. The crankshaft must be ground corresponding to the bearing shell width while maintaining the axial clearance.

Mounting in bearings

1 Clean bearing points in the crankcase and bearing caps with chamois leather only.

2 Fit bearing shell halves in the correct order in the crankcase and in the crankshaft bearing caps. Take particular care to ensure that the retaining lugs of the bearing shells are fitted correctly in the grooves and in the basic bores. Oil bearing shells.

Note: The main bearing shells in the crankcase have an oil hole and must be aligned with the lubrication hole in the crankcase.

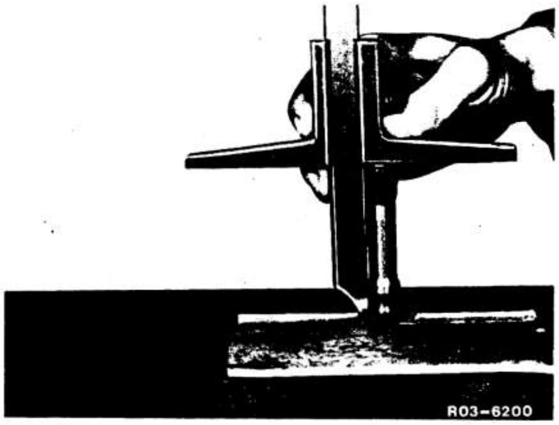


3 Insert bearing caps with bearing shells in the crankcase in accordance with the bearing identification markings.

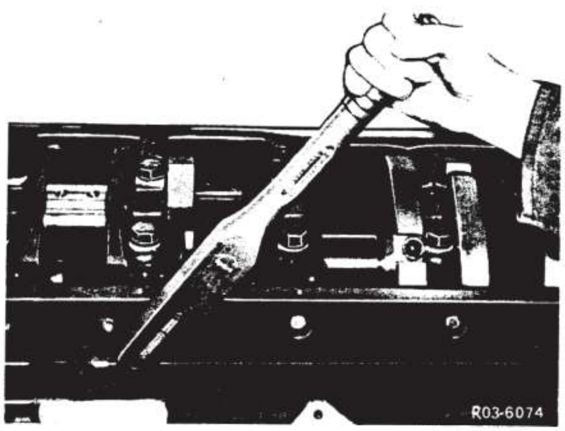
4 Measure the shank length of the vertical crankshaft bearing cap bolts.

Note: The crankshaft bearing cap bolts can be reused up to a maximum shank length of 156 mm.

5 Initially tighten vertical crankshaft bearing cap bolts in three stages to 300 Nm and then tighten further by 90° to 100° tightening angle.

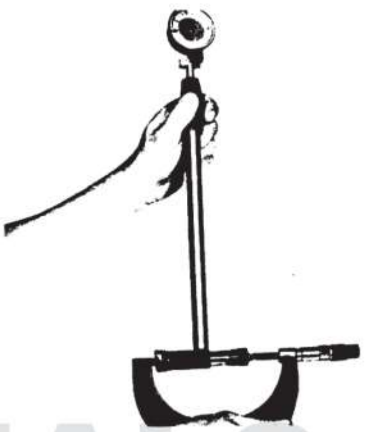


6 Screw in side crankshaft bearing cap bolts and tighten to 80 Nm.



7 Set 100–160 mm ∅ internal measuring instrument and dial gauge with 100–125 mm micrometer to the zero size of the crankshaft journals.

Dial gauge 001 589 53 21 00



R03-6014

8 Measure crankshaft bearing bore with set 100–160 mm ∅ internal measuring instrument at three points (vertically and 30° from the top and bottom of the parting lines).

Note: The values specified in the table must be maintained.

9 Unscrew the crankshaft bearing caps once again.

Dial gauge 001 589 53 21 00

Mounting in bearings and installation

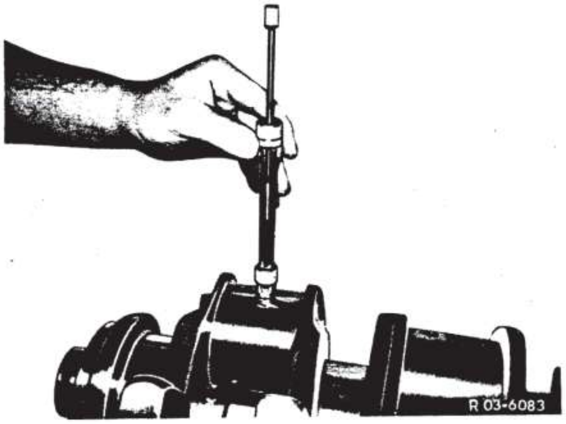
1 Working from the oil pump side, blow out the oil ducts of the crankcase with compressed air.

2 Throroughly clean crankshaft, bearings and bearing seats with chamois leather, clean oil ducts of crankshaft with wire brush and blow with compressed air.

3 Check hardness of crankshaft journals with hardness tester.

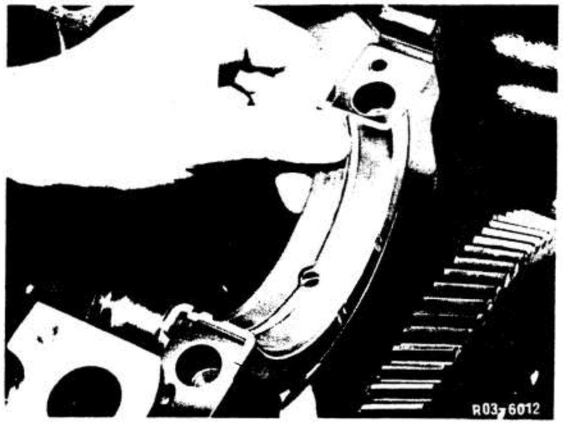
Note: A conversion table is supplied with the hardness tester.

Hardness tester 000 589 20 21 00



4 Fit bearing shell halves in the correct order in the crankcase and in the crankshaft bearing caps. Take particular care to ensure that the retaining lugs of the bearing shells are correctly fitted in the grooves and in the basic bores.

Note: The main bearing shells in the crankcase have an oil hole and must be aligned with the lubrication hole in the crankcase.

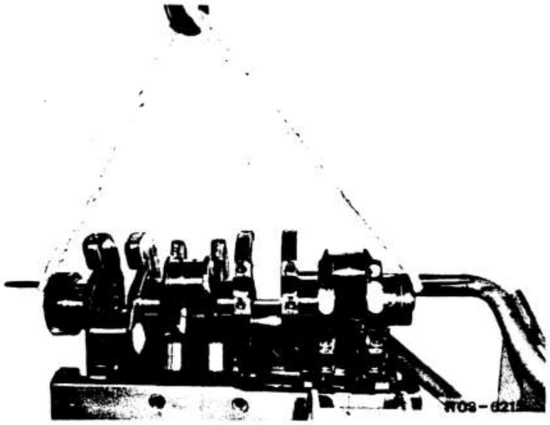


5 Coat contact surfaces of the bearing shells with engine oil.

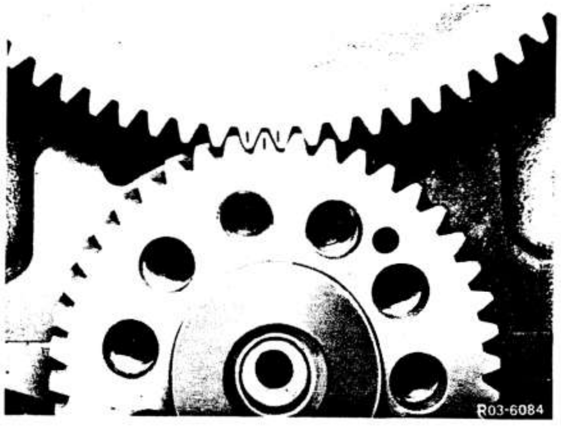
6 Screw in a guide pin at the front and rear ends of the crankshaft, attach a hemp rope to the guide pins and lift crankshaft with lifting gear.

7 Place crankshaft in position in the bearing shells.

Guide pin 403 589 02 63 00



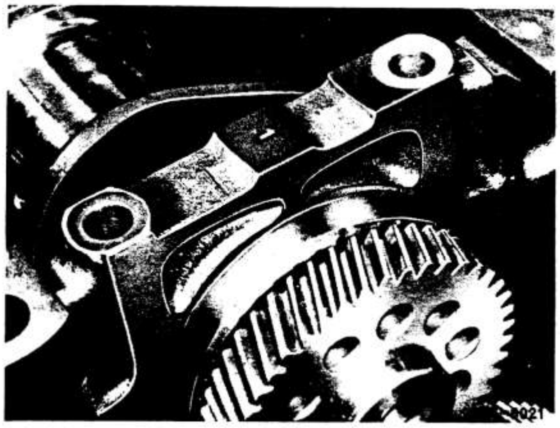
Note: Take particular care to ensure that the tooth of the crankshaft gearwheel marked with 1 engages between the teeth of the camshaft gearwheel also marked with 1–1.



8 Fit crankshaft bearing caps with bearing shells. Ensure the markings of the corresponding bearings agree.

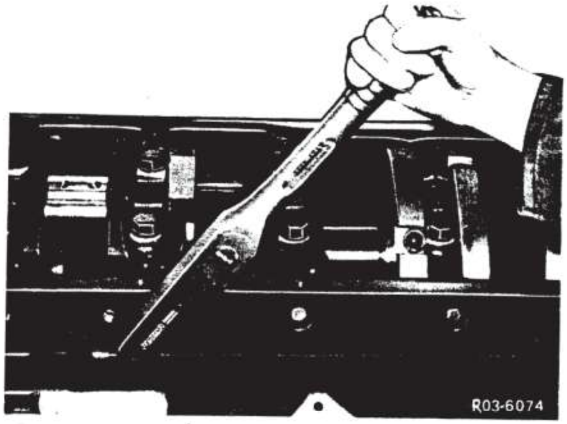
9 Measure the shank length of the vertical crankshaft bearing cap bolts.

Note: The crankshaft bearing cap bolts can be reused up to a maximum shank length of 156 mm.



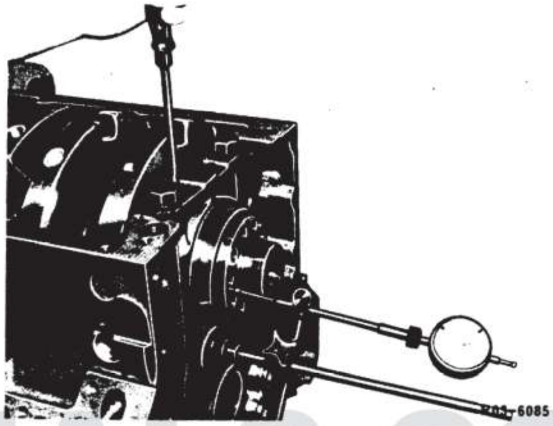
10 Initially tighten the vertical crankshaft bearing cap bolts in 3 stages to 300 Nm and then tighten further by 90° to 100° tightening angle.

11 Screw in side crankshaft bearing cap bolts and tighten to 80 Nm.



12 Mount holder together with dial gauge on the crankcase and check the axial clearance of the crankshaft.

Holder	363 589 02 21 00
Dial gauge	001 589 53 21 00



03 – 4460 Grinding Crankshaft

Crankshaft dimensions

Allowance	Main bearing journal ⌀	Width for thrust bearing journal	Big end bearing journal ⌀
Standard	104.000 103.980	38.062 38.000	90.000 89.980
Oversize allowance 0.10	103.900 103.880		89.900 89.880
Oversize allowance 0.25	103.750 103.730	38.562 38.500	89.750 89.730
Oversize allowance 0.50	103.500 103.480		89.500 89.480
Oversize allowance 0.75	103.250 103.230	39.062 39.000	89.250 89.230
Oversize allowance 1.00	103.000 102.980		89.000 88.980
Width of big end bearings	441.906/907 442, A, LA 443 LA		71.120 71.000
	441.905/912/913/914 441 LA		38.160 38.000
	442 A1), LA1) 444 A1), LA1)		71.120 71.000

1) Industrial engine

Repair data

Hardness of crankshaft journals: Rockwell hardness HRC	56 ± 3
Permissible conicity of crankshaft journals	max. 0.01
Permissible out-of-round of crankshaft journals	max. 0.02
Permissible run-out of crankshaft when resting on the outer crankshaft bearing journal	0.06
Permissible radial run-out of flange for crankshaft gearwheel when resting on the outer crankshaft bearing rournal	0.02
Permissible lateral run-out of flange for crankshaft gearwheel when resting on the outer crankshaft bearing journal	0.02
Permissible deviation in parallel alignment of the crankshaft gearwheel	0.03
Permissible imbalance of the crankshaft with counterweights, without flywheel at the outer main bearings	60 g cm
Fillet radii at the crankshafts and big end bearing journals	3.5–4
Permissible misalignment of the big end bearings with respect to the crankshaft bearings, referred to bearing length	0.01

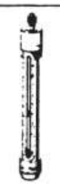
Tightening torques

Counterweight to crankshaft	initial torque	140 to 160 Nm 90° to 100° tightening
Elongation	max.	84.5 mm

Workshop equipment

Crankshaft grinding machine

Special tools



000 589 20 21 00

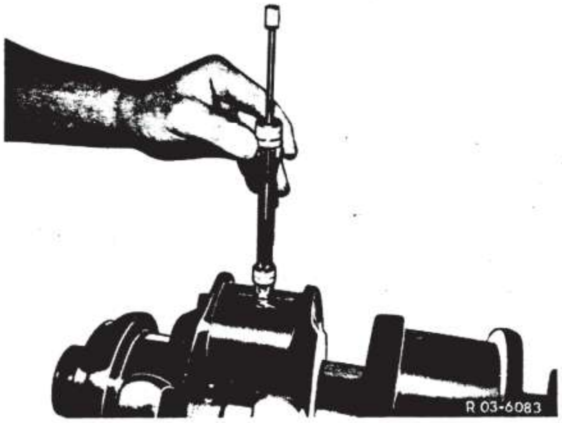
Grinding the crankshaft

1 Unscrew counterweights.
Before removing, check whether the counterweights are marked with respect to the crankshaft. If not, the counterweight must be correspondingly marked with punch numbers to ensure they are reinstalled in the same position.

2 Remove crankshaft gearwheel.

3 After cleaning the crankshaft, check alignment, out-of-round of the journals and the bearing points as regards hardness and cracks. Cracked and bent crankshafts must be scrapped. Crankshafts which are too soft must be rehardened. The shafts must be recentered before grinding. For checking and recentering purposes, the crankshaft is held at the first and last main bearing journal. If the bearing points are out-of-round or scored, then they must be ground to the next oversize.

Hardness tester 000 589 20 21 00

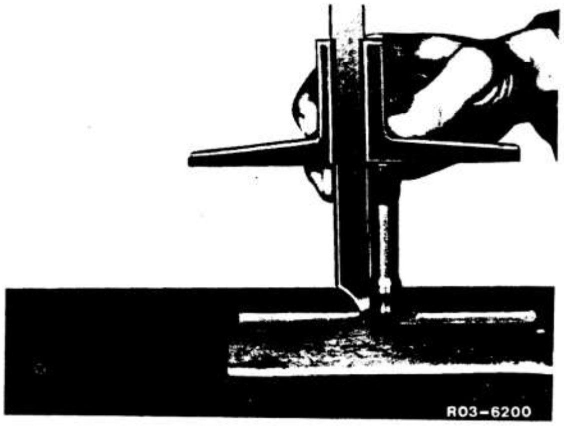


Note: The oversizes specified in the table must be precisely maintained, where, of course all journals of the main bearings must be ground to the same oversize allowances. The width of the thrust bearing changes together with the oversize allowances, hereby rendering remachining of the contact surface on the crankshaft necessary. When regrinding the big end bearing journals, the same oversize must also be selected for all big end bearing journals, however, the oversize allowances for big end journals and main bearing journals may differ.

4 The fillet radii at the main bearing and big end bearing journals must be maintained on all accounts.

5 The surface of the journals must be lapped after grinding.

6 Measure shank length of securing bolts for the counterweights.



Note: The bolts can be reused up to a maximum shank length of 84.5 mm.

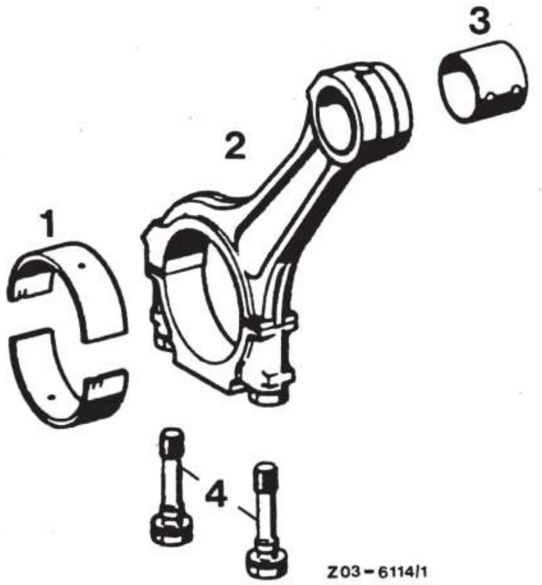
7 Fit counterweights and tighten to 140 to 160 Nm. Final torque 90° to 100° tightening angle.

Note: The markings on the counterweights must agree with the markings on the crankshaft.

8 For installation, thoroughly clean oil ducts with wire brush and blow clean with compressed air.

03 – 6310 Mounting Connecting Rod in Bearings

Connecting rod removed



1 Big end bearing shell
2 Connecting rod with bearing cap
3 Small end bearing
4 Connecting rod bolt. . . . . Initial torque 100 Nm
Final torque 90° to 100° tightening angle
Elongation: Can be reused up to max. shank length 68.5 mm.

Big end bearing shells

Oversize allowances		Big end bearing ∅ when installed
Standard		90.106 90.064
Oversize allowance 0.1		90.006 89.964
Oversize allowance 0.25		89.856 89.814
Oversize allowance 0.5		89,606 89.564
Oversize allowance 0.75		89,356 89.314
Oversize allowance 1.00		89.106 89.064
Bid end bearing width	441.906/907 442, A, LA 443, LA	31.0 30.8
	441.905/912/913/914 441 LA	24,7 24.5
	442 A[1], LA[1] 444 A[1], LA[1]	31.0 30.8
Basic bore ∅, big end bearing		95.022 95.000
Basic bore ∅, small end bearing		50.630 50.600
Length of connecting rod from centre of big end bearing bore to center of piston pin bore		256 ± 0.05
Width of connecting rod at piston pin boss	39.0–0.3	
Width of connecting rod at big end bearing boss	441.906/907 442, A, LA 443, LA	35.380 35.310
	441.905/912/913/914 441 LA	32.380 32.341
	442 A[1], LA[1] 444 A[1]/444 LA[1]	35.380 35.310

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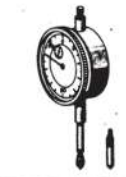
[1] Industrial engine

Special tools



001 589 53 21 00

Workshop equipment

Internal measuring instrument 50 – 100 mm

Micrometer 75 – 100 mm

Note: Irrespective of the oversize allowances, the bearing shells for the big end bearings are supplied ready for installation ex factory. Therefore, the bearings require no reworking whatsoever.

Mounting connecting rod in bearings

1 Clean bearing points in the connecting rod and bearing cap with chamois leather only.

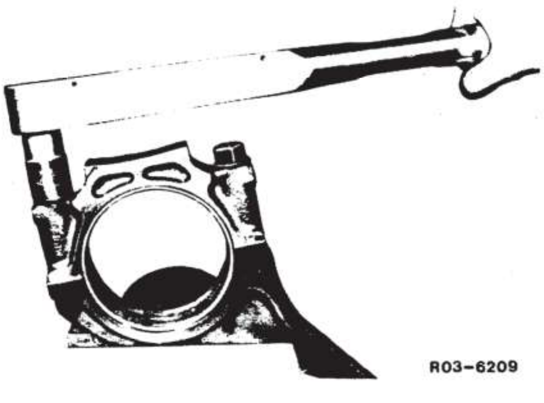
2 Fit bearing shell halves in the correct order in the connecting rods and bearing caps. Take particular care to ensure that the retaining lugs of the bearing shells fit correctly in the grooves of the basic bores.

3 Place bearing cap with bearing shell on the connecting rod corresponding to the bearing identification markings (numbers must be on one side).

6

4 Initially tighten securing bolts with torque wrench in two stages to 100 Nm. Final torque 90° to 100° tightening angle.

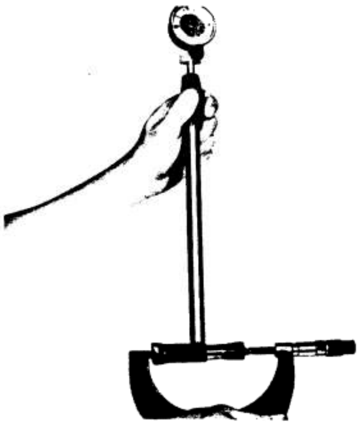
Note: To prevent the connecting rod twisting, clamp connecting rod just under the big end bearing in a vice (use soft jaw guards).



R03–6209

5 Set 50–100 mm internal measuring instrument and dial gauge together with 75–100 mm micrometer to the zero size of the big end bearing bore.

Dial gauge 001 589 53 21 00



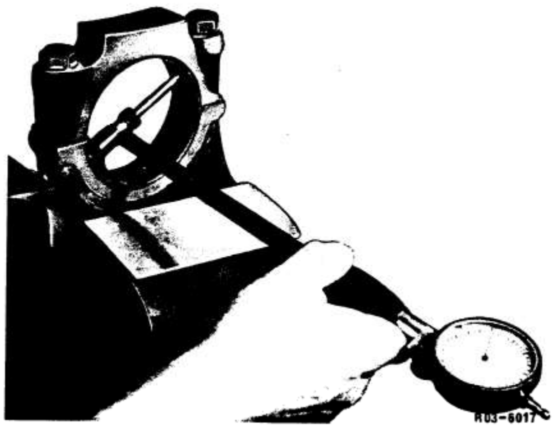
R03-6014

6 Measure big end bearing bore with set 50–100 mm ∅ internal measuring instrument at three points (vertically and 30° from top and bottom of parting lines).

Note: The values specified in the tables must be maintained.

7 Unscrew bearing caps once again.

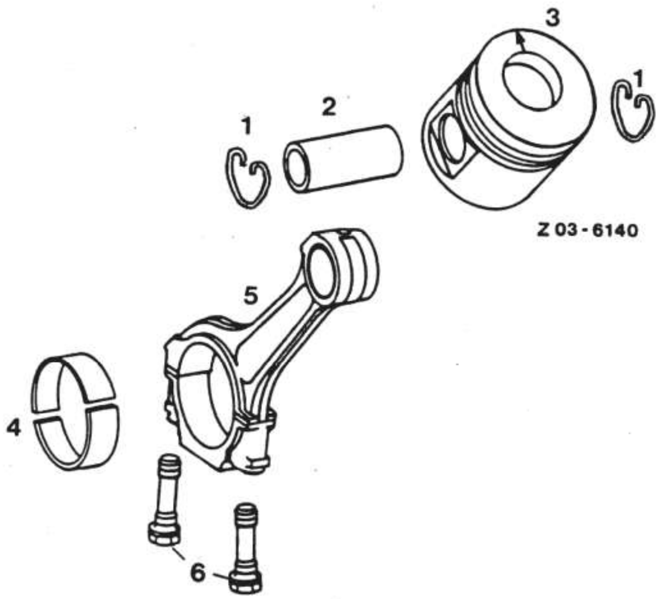
Dial gauge 001 589 53 21 00



R03-6017

Removal of Pistons

Cylinder heads and oil pan removed



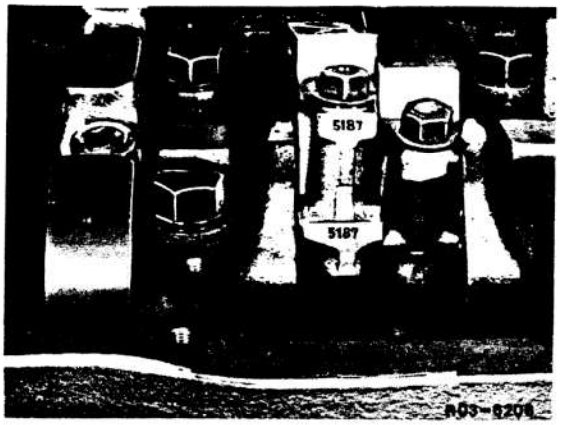
1 Retaining ring
2 Piston pin
3 Piston
4 Big end bearing shell
5 Connecting rod
6 Connecting rod bolt

Removal

1 Remove combustion residue above the level of the piston top land in the cylinder liner with a scraper (do not damage running surface) in order to avoid damage to the piston rings).

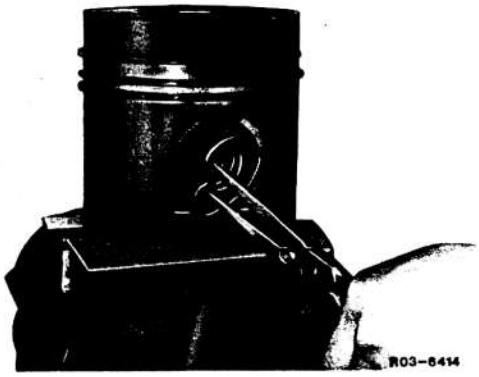
2 Unscrew big end bearing cap from the connecting rod.

Note: Take particular care to ensure that the bearing caps are marked with respect to the connecting rod.

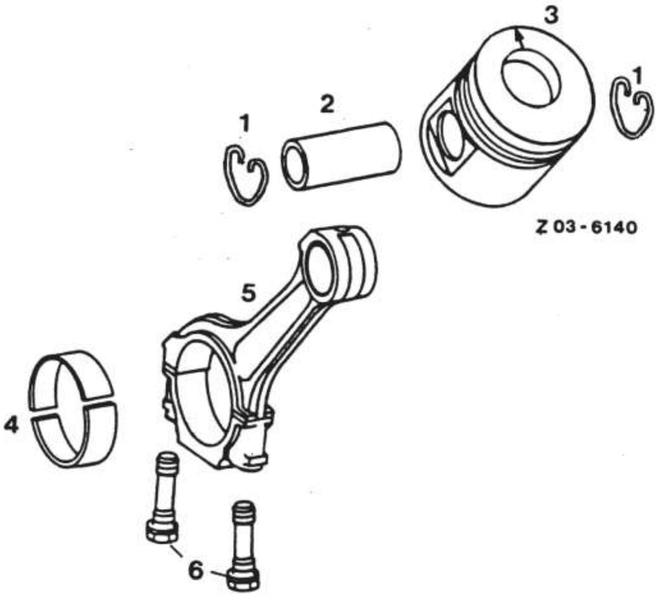


3 Press out connecting rod with piston from below out of the cylinder liner and remove.

4 Clamp connecting rod together with piston in vice (use soft vice jaw guards). Lever out piston pin retaining ring, press out piston pin, remove piston.



03 – 7124 Installation of Pistons



1	Retaining ring	
2	Piston pin	
3	Piston	Special tool 000 589 38 31 00, arrow pointing towards center of engine
4	Big end bearing shell	
5	Connecting rod with cover	
6	Connecting rod bolt	Initial torque 100 Nm Final torque 90° to 100° tightening angle **Elongation:** Can be reused up to max. shank length 68.5 mm.

Data

Engine			441 442 443	441 LA 442 A, LA 443 LA 444 A[1], LA[1]
Piston ⌀			130	128
Piston pin bore			46.003 46.020	
Piston projection from upper edge of crankcase			0.07 0.43	
Big end bearing clearance, radial			0.064–0.126	
Big end bearing clearance, axial			0.240–0.500	
Piston pin clearance – small end bearing			0.055–0.070	
Piston pin clearance – piston			0.003–0.030	
Piston code letter	"B"	Assignment cylinder liner code letter	B and C	
	"C"		B, C and D	
	"D"		C, D and E	
	"E"		D and E	

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[1] Industrial engine

Special tools

000 589 38 31 00

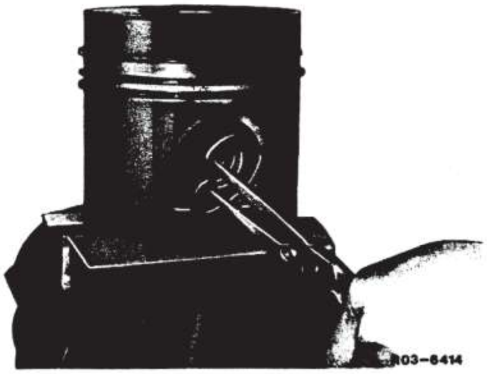
001 589 53 21 00

Installation

1 Insert the connecting rod in the piston such that the longer side of the obliquely split piston rod agrees with the direction indicated by the arrow on the piston.

2 Insert piston pin and secure with retaining rings.

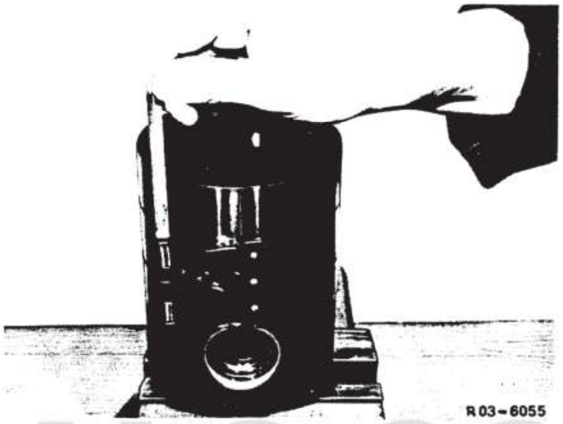
Note: If used pistons are reinstalled, the top piston ring must be renewed in the case of the naturally aspirated engines and the second piston ring in the case of the turbocharged engines.



R03-6414

3 Coat piston with engine oil. Offset piston ring joints by 180° one after the other. Loosely slide piston ring compressor over the piston rings and tighten to the outside diameter of the piston such that the sleeve can still just be displaced.

Piston ring compressor 000 589 38 31 00



R03-6055

4 Fit big end bearing shell in connecting rod. Ensure the lug fits correctly in the groove of the connecting rod.

5 Coat running surfaces of the big end bearing shells with oil.

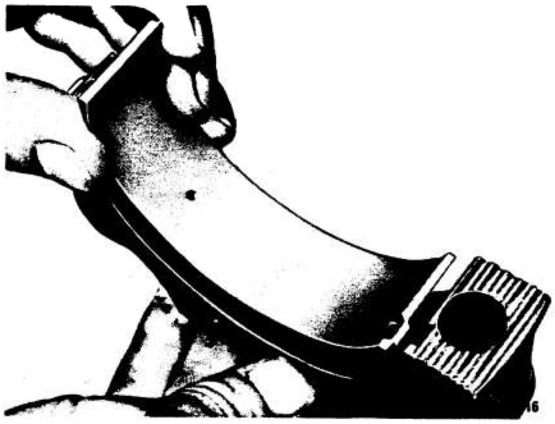
R03-6009

6 Insert piston, arrow pointing in direction of engine center, in the cylinder liner.

7 Further push in piston until the big end bearing rests on the bearing journal of the crankshaft.

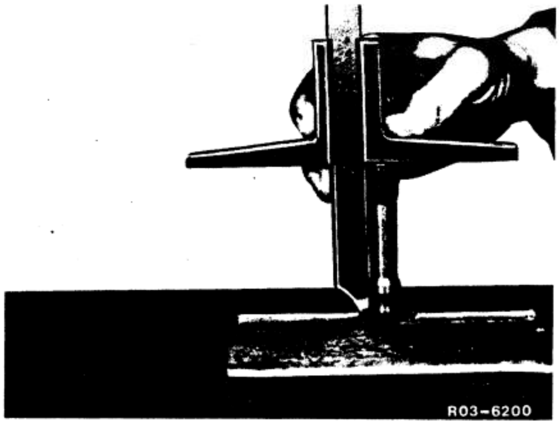
R03-6019/1

8 Fit big end bearing shell in big end bearing cap. Take particular care to ensure that the lug fits correctly in the groove of the bearing cap. Coat running surface of big end bearing shells with oil.



9 Measure shank length of connecting and bolts.

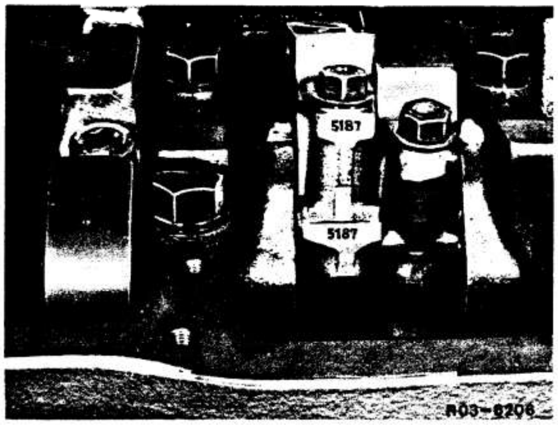
Note: The connecting rod bots can be reused up to a max. shank length of 68.5 mm.



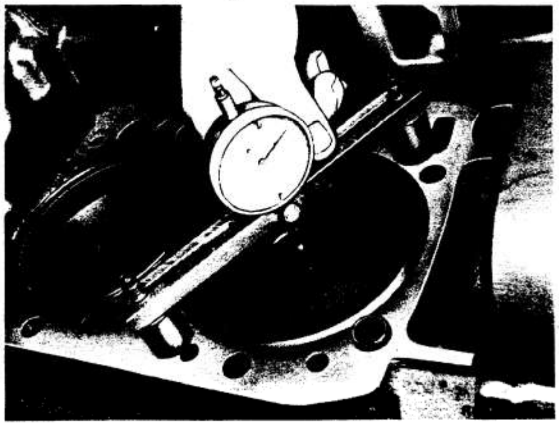
10 Fit bearing cap and screw in big end bearing bolts by hand.

Note: Ensure the identification marking on the bearing cap agrees with that on the connecting rod.

11 Alternately tighten bolts with torque wrench in two stages to 100 Nm and then further tighten by 90° to 100° tightening angle.

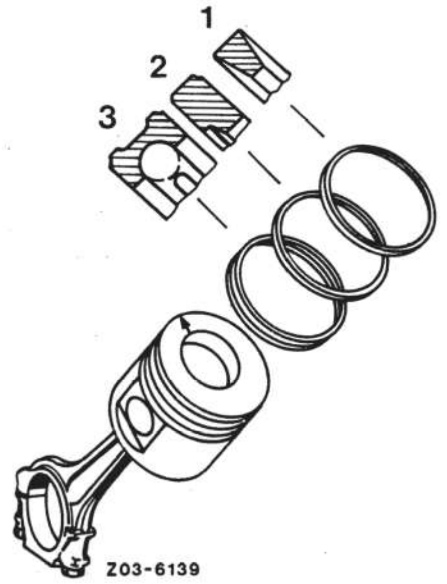


12 Check projection between piston crown and mating surface of crankcase with the piston in TDC position.



Renewing Piston Rings

Piston removed



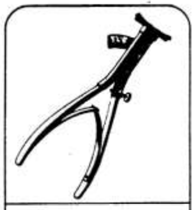
1 Keystone ring
2 Taper face ring
3 Spring loaded chamfered oil control ring

Piston rings

Engine			441 442 443	441 LA 442 A, LA 443 LA 444 A[1], LA[1])
Piston diameter			130	128
Piston ring groove	I		Keystone ring	Keystone ring
	II		Taper face ring	Taper face ring
	III		Spring loaded chamfered oil control ring	Spring loaded chamfered oil control ring
Piston ring gap clearance	I	new	0.35–0.50	0.35–0.50
		repair max.	1.0	1.0
	II	new	0.35–0.50	0.35–0.50
		repair max.	1.0	1.0
	III	new	0.25–0.40	0.25–0.40
		repair max.	0.8	0.8

[1] Industrial engine

Special tools

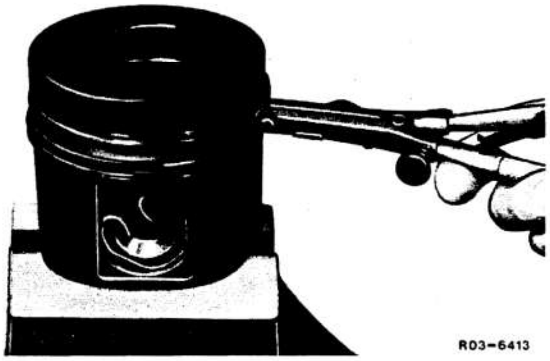

000 589 37 37 00

Renewing piston rings

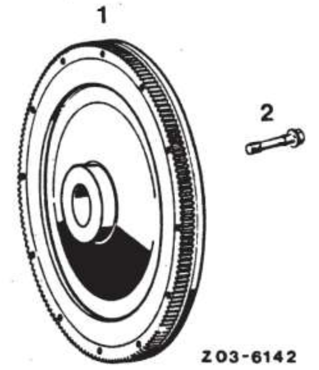
1 Set piston ring pliers to 128 or 130 mm ∅ with adjusting screw.

2 The piston rings can be removed and installed with this setting.

Piston ring pliers 000 589 37 37 00

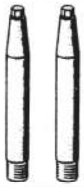


03 – 8003 Removal and Installation of Flywheel



1 Flywheel	Special tool 403 589 02 63 00
2 Flywheel bolt	Initial torque 200 to 220 Nm Final torque 90° to 100° tightening angle Elongation: Can be reused up to max. shank length 75 mm

Special tools


403 589 02 63 00

Removal

1 Slacken bolts holding the flywheel and unscrew.

2 Screw guide pins into two opposing threaded holes.

3 Slide flywheel onto the guide pins and remove. Unscrew guide pins from the crankshaft.

4 Clean flywheel and check for damage.

Guide pin 403 589 02 63 00

Installation

1 Screw guide pins into two opposing threaded holes of the crankshaft.

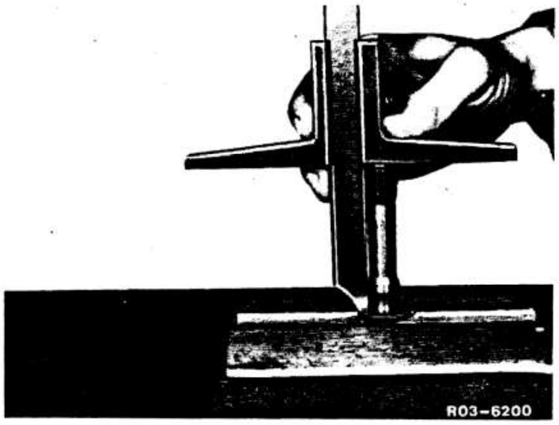
2 Place flywheel on the guide pins and press against the contact surface of the crankshaft.

Guide pin 403 589 02 63 00

Note: Ensure that the centering pin in the crankshaft gearwheel agrees with the centering bore hole in the flywheel.

3 Measure shank length of flywheel bolts.

Note: The flywheel bolts can be reused up to a max. shank length of 75 mm.



4 Lightly oil all securing bolts at the thread and contact surface, screw in and lightly tighten, unscrew guide pins from the crankshaft and replace by bolts.

5 Tighten securing bolts crosswise to 200 to 220 Nm and then further tighten by 90° to 100° tightening angle.

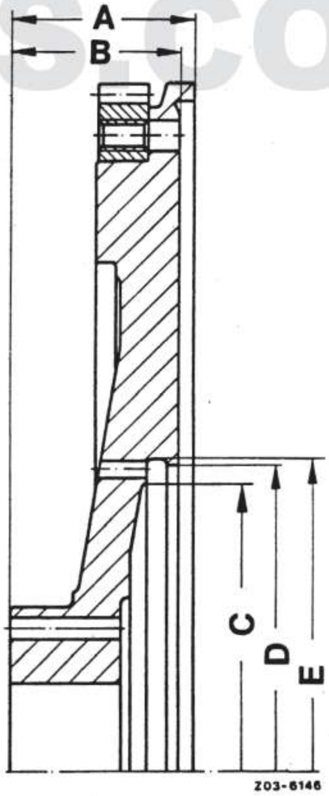
R03-6201

03 – 8042 Machining Flywheel

Flywheel removed

Data

Engine model		441.906 441.907 442.905 442.908 442.909	441.951 441.961	441.905 441.912 441.913 441.914 442.906 442.907 442.914 442.915 442.916 442.917 442.920 442.921 442.959 442.963 442.964 442.965 442.966 442.982 442.983 443.905	442.950 442.951 442.952 442.953 442.958 442.962 442.980	443.980
Diameter for starter ring gear	Standard	432,645 432,490	432,645 432,490	432,645 432,490	432,645 432,490	432,645 432,490
	Oversize 0.5	432,145 431,990	432,145 431,990	432,145 431,990	432,145 431,990	432,145 431,990
Inside diameter of starter ring rear	Standard	432,155 432,000	432,155 432,000	432,155 432,000	432,155 432,000	432,155 432,000
	Oversize 0.5	431,655 431,500	431,655 431,500	431,655 431,500	431,655 431,500	431,655 431,500
Overlap of starter ring gear		0,333 0,645	0,333 0,645	0,333 0,645	0,333 0,645	0,333 0,645
Permissible lateral run-out of starter ring gear when fitted		0,5	0,5	0,5	0,5	0,5
Fitting temperature of starter ring rear		200° to 230° C	200° to 230° C	200° to 230° C	200° to 230° C	200° to 230° C
Diameter for holding the bearing ring		115,015 114,980	115,015 114,980	115,015 114,980	115,015 114,980	115,015 114,980
Minimum distance between clutch surface and support flange of the flywheel (for repair) dimension B		60	72	60	60	–
Overall width of flywheel dimension A		67	79	70	67	67
Diameter Dimension C		207	236	228	236	–
Diameter Dimension D		216	245	235	245	–
Diameter Dimension E		220	249	240	249	–
Hole pitch diameter for clutch		450	410	450	410	–



Machining flywheel

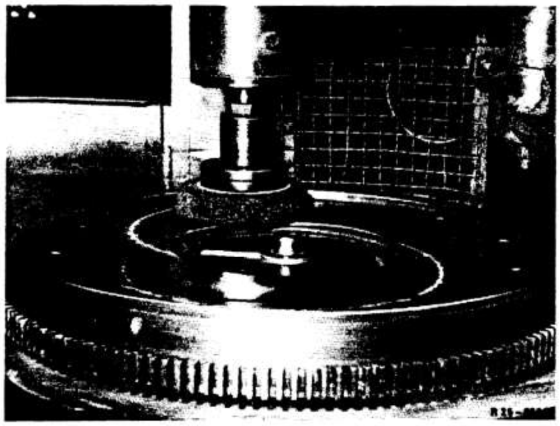
Note: After removing the clutch, clean all parts including the flywheel.

1 Check flywheel for cracks and scoring.

2 Check the flatness of the contact surface with a straightedge.

3 Check support surface and threaded holes for holding the clutch housing.

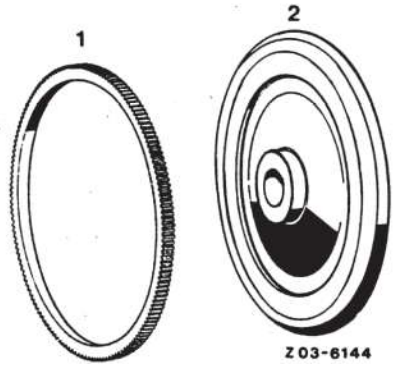
4 Before removing and remachining the flywheel, check whether remachining is possible. The flywheel may be remachined by a maximum of the permissible material removal at the clutch surface (friction surface)



5 The peak-to-valley height of the friction surface is 15 μm. If the peak-to-valley height is too great, the wear of the clutch lining increases while clutch parting difficulties may be caused by a peak-to-valley height which is too low.

03 – 8302 Renewing Starter Ring Gear

Flywheel removed



1 Ring gear. . . . . heat to 200 to 230° C and press fit
2 Flywheel

Data

Diameter for mounting ring gear (standard)	432,645 432,490
Diameter for mounting ring gear (oversize allowance 0.5)	432,145 431,990
Inside diameter of ring gear (standard)	432,155 432,000
Inside diameter of ring gear (oversize allowance 0.5)	431,655 431,500
Overlap of ring gear	0,335 0,645
Press fit of ring gear at a temperature of	220–230° C (yellow annealing colour)
Permissible lateral run-out of fitted ring gear	0,5
Width of ring gear	18,6 18,4

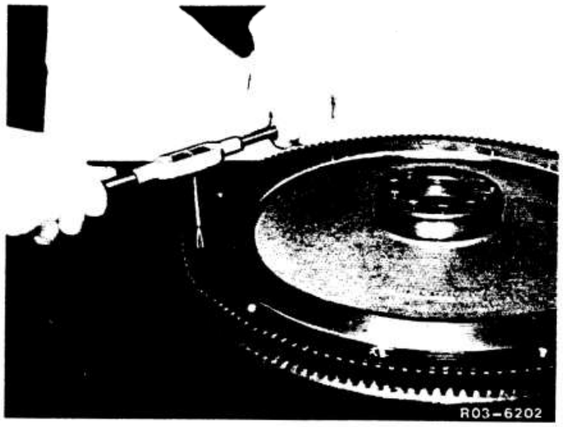
Renewing starter ring gear

1 Quickly heat ring gear with welding flame and remove.

2 Heat new ring gear to a temperature of 200 to 230° C (yellow annealing colour) and press fit.

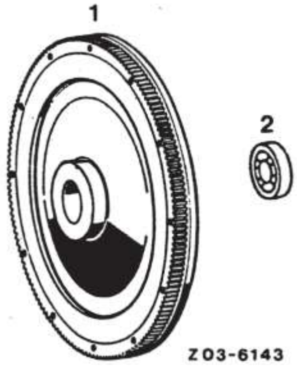
3 In the case of engines with a hole pitch diameter of 450 mm for mounting the clutch, after assembly the ring gear must be drilled and an M 10 x 1.5 thread tapped.

Note: After press fitting, the maximum lateral run-out of the ring gear must not be exceeded. Grease the ring-gear before putting into operation.



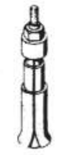
03 – 8400 Renewing Guide Bearing in Flywheel

Flywheel removed

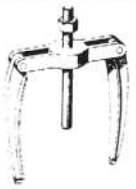


1 Flywheel
2 Guide bearing .... Special tool 000 589 27 33 00, 000 589 34 33 00, 403 589 02 63 00, 403 589 05 15 00

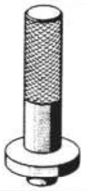
Special tools



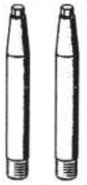
000 589 27 33 00



000 589 34 33 00



403 589 05 15 00

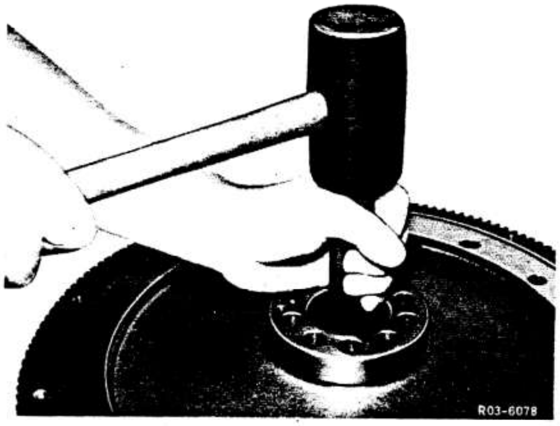


403 589 02 63 00

Renewing guide bearing

1 Drive out guide bearing in flywheel with drift.

Drift 403 589 05 15 00


R03-6078

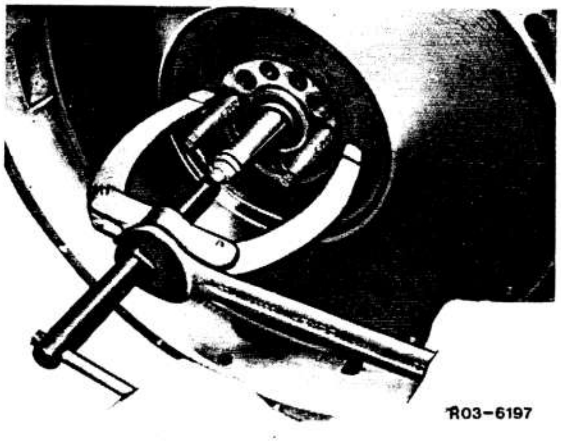
2 Place new guide bearing in position of flywheel and drive in with drift.

Drift 403 589 05 15 00

R03-6079

Note: The guide bearing can also be removed with the flywheel installed with the aid of an internal extractor and countersupport.
For this purpose, remove the securing bolts and screw in the two guide pins in opposing holes to secure the flywheel.

Internal extractor	000 589 27 33 00
Countersupport	000 589 34 33 00
Guide pin	403 589 02 63 00


R03-6197

05 – 1122 Setting Valve Clearance

Method 1

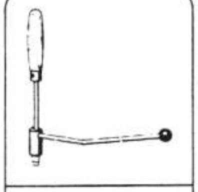
Data

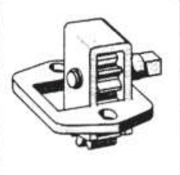
Engine	441/441 LA 442/442 A/442 LA 443/443 LA 444 A[1]/444 LA[1]	
Valve clearance	Inlet Exhaust	0.40 0.60
441 441 LA	Firing order Overlap	1–4–2–5–3–6 5–3–6–1–4–2
442 442 A 442 LA	Firing order Overlap	1–5–7–2–6–3–4–8 6–3–4–8–1–5–7–2
443 443 LA	Firing order Overlap	1–6–5–10–2–7–3–8–4–9 7–3–8–4–9–1–6–5–10–2
444 A[1] 444 LA[1]	Firing order Overlap	1–12–5–8–3–10–6–7–2–11–4–9 6–7–2–11–4–9–1–12–5–8–3–10

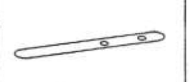
[1] Industrial engine

Tightening torques	Nm
Lock nut on adjusting screw	50
Cylinder head cover	25

Special tools


321 589 00 11 00


407 589 00 63 00


422 589 01 23 00

617 589 04 23 00

617 589 00 40 00

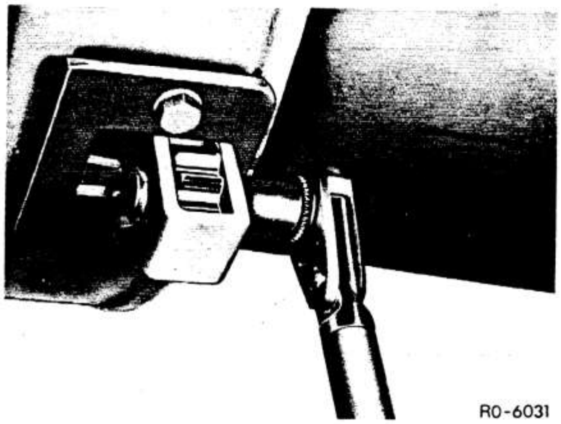
Setting valve clearance

Note: Set valve clearance when engine is cold or warm (20 minutes after switching off engine at the earliest).

1 Remove cylinder head covers.

2 Attach cranking device with bolts 8 x 20 DIN 933 to the timing case and crank the engine until the piston of the cylinder to be set is in the top dead center position. The valves must be closed, the rocker arms completely slack and it must be possible to easily turn the push rods in the ball sockets. The valves overlap at the synchronously running cylinder (e.g. cylinders No. 1 and 6 in OM 442).

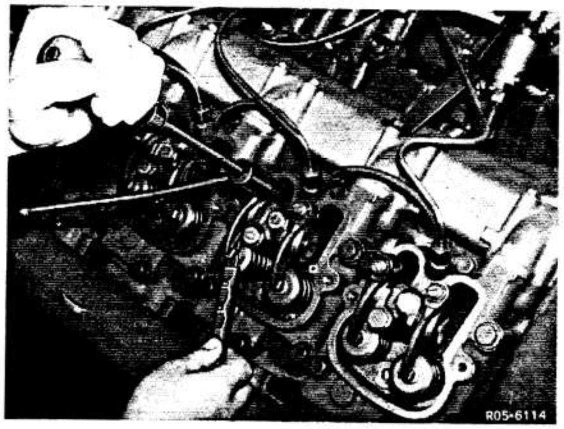
Cranking device	407 589 00 63 00


R0-6031

3 Slide feeler gauge with feeler gauge holder between inlet valve and rocker arm or between outlet valve and rocker arm.

The valve clearance is set correctly when the feeler gauge can be pulled through with slight resistance.

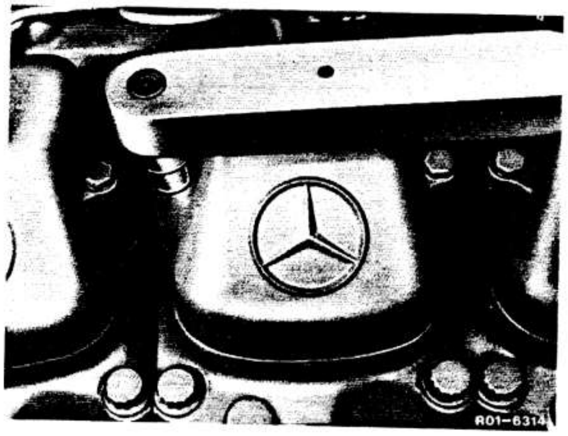
Valve adjusting wrench	321 589 00 11 00
Feeler gauge holder	617 589 00 40 00
Feeler gauge 0.40 mm	617 589 04 23 00
Feeler gauge 0.60 mm	422 589 01 23 00


R05-6114

4 If it is necessary to correct the valve clearance, fit valve adjusting wrench on the adjusting screw, loosen lock nut and correct valve clearance. Retighten lock nut while firmly holding adjusting screw.

5 Fit cylinder head covers with gaskets and tighten securing bolts to 25 Nm.

6 Detach cranking device from timing case.


R01-6314

Method 2

Data

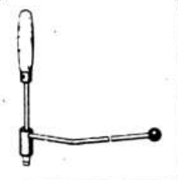
Engine	441/441 LA 442/442 A/442 LA 443/443 LA 444 A[1]/444 LA[1]

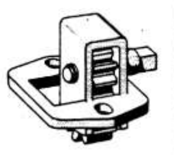
Engine	Cylinder 1 in:	Inlet valves to be set	Outlet valves to be set
441	Overlap TDC	2, 4, 5	3, 5, 6
441 LA	Ignition TDC	1, 3, 6	1, 2, 4
442			
442 A	Overlap TDC	2, 5, 6, 7	3, 4, 6, 8
442 LA	Ignition DTC	1, 3, 4, 8	1, 2, 5, 7
443	Overlap TDC	2, 3, 5, 6, 7, 10	3, 4, 7, 8
443 LA	Ignition TDC	1, 4, 8, 9	1, 2, 5, 6, 9, 10
444 A[1]	Overlap TDC	3, 5, 6, 8, 10, 12	2, 4, 6, 7, 10, 11
444 LA[1]	Ignition TDC	1, 2, 4, 7, 9, 11	1, 3, 5, 8, 9, 12

[1] Industrial engine

Tightening torques	Nm
Lock nut on adjusting screw	50
Cylinder head cover	25

Special tools


321 589 00 11 00


407 589 00 63 00

617 589 00 40 00

617 589 04 23 00

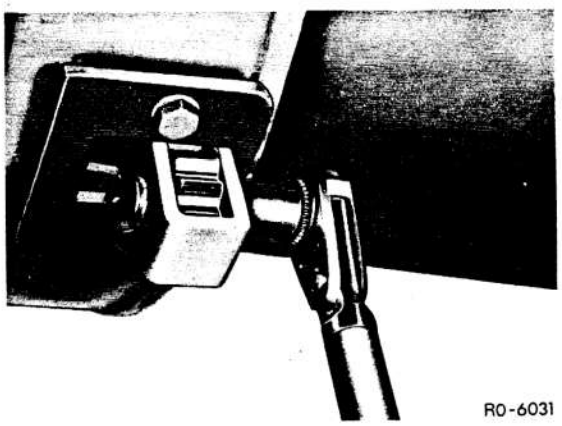
422 589 01 23 00

Note: Set valve clearance when the engine is cold or warm (20 minutes after switching off the engine at the earliest).

1 Unscrew cylinder head cover and remove. Check gasket for damage, renew if necessary.

2 Attach cranking device with bolts 8 x 20 DIN 933 to the timing case and crank engine in correct direction of rotation until the TDC marking is aligned with the edge in the inspection hole.

3 Check whether the cylinder No. 1 is in the ignition TDC or in the overlap TDC position (in ignition TDC, both valves are closed, the rocker arms completely slack and the push rods must turn easily).


RO-6031

Cranking device 407 589 00 63 00

The following valves can be set in ignition TDC:

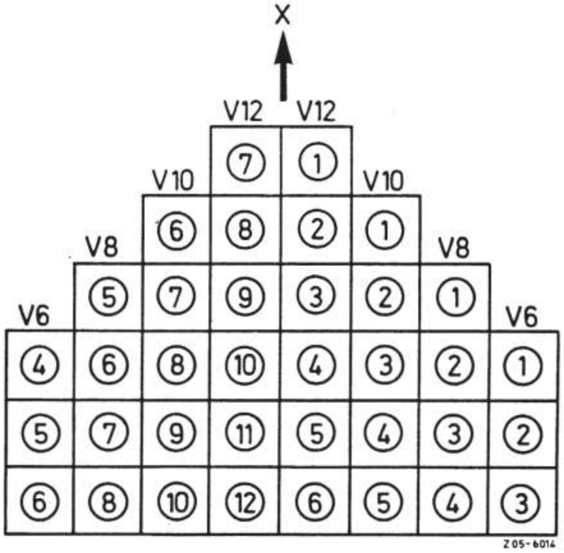
Engine	Inlet	Exhaust valve
441/441 LA	1, 3, 6	1, 2, 4
442/442 A/LA	1, 3, 4, 8	1, 2, 5, 7
443/443 LA	1, 4, 8, 9	1, 2, 5, 6, 9, 10
444 A[1]/LA[1]	1, 2, 4, 7, 9, 11	1, 3, 5, 8, 9, 12

[1] Industrial engine

The following valves can be set in overlap TDC:

Engine	Inlet valve	Exhaust valve
441/441 LA	2, 4, 5	3, 5, 6
442/442 A/LA	2, 5, 6, 7	3, 4, 6, 8
443/443 LA	2, 3, 5, 6, 7, 10	3, 4, 7, 8
444 A[1]/LA[1]	3, 5, 6, 8, 10, 12	2, 4, 6, 7, 10, 11

[1] Industrial engine



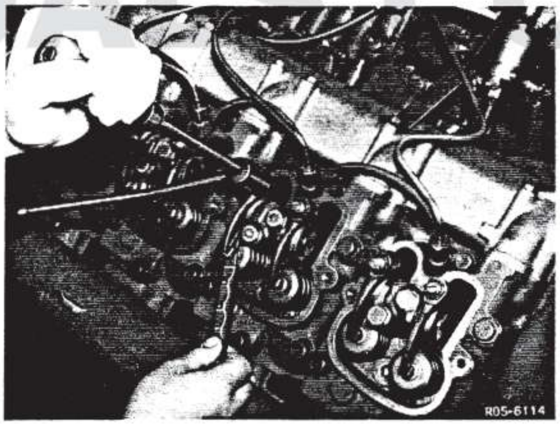
4 Slide feeler gauge with feeler gauge holder between inlet valve or exhaust valve and rocker arm.

The valve clearance is set correctly when the feeler gauge can be pulled through with slight resistance.

X = Forward direction

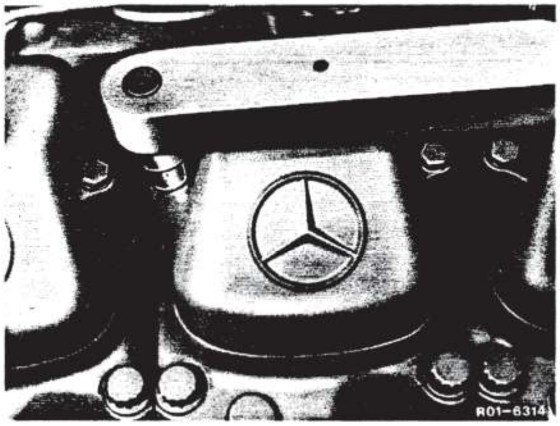
5 If it is necessary to correct the valve clearance, fit the valve adjusting wrench on the adjusting screw, loosen lock nut and correct valve clearance. Retighten lock nut while firmly holding the adjusting screw.

Valve adjusting wrench	321 589 00 11 00
Feeler gauge holder	617 589 00 40 00
Feeler gauge 0.40 mm	617 589 04 23 00
Feeler gauge 0.60 mm	422 589 01 23 00



6 Fit cylinder head covers with gaskets and tighten securing bolts to 25 Nm.

7 Detach cranking device from timing case.



05 – 1500 Checking Valve Lift

Valve lift

Engine		441 442 443	441 LA 442 A, LA 443 LA 444 A[1], LA[1]
Valve lift at specified valve clearance	Inlet	11.95 12.35	11.90 12.30
	Exhaust	11.90 12.30	11.85 12.25

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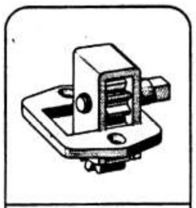
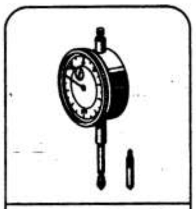
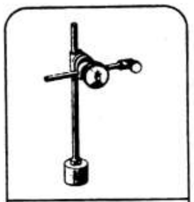
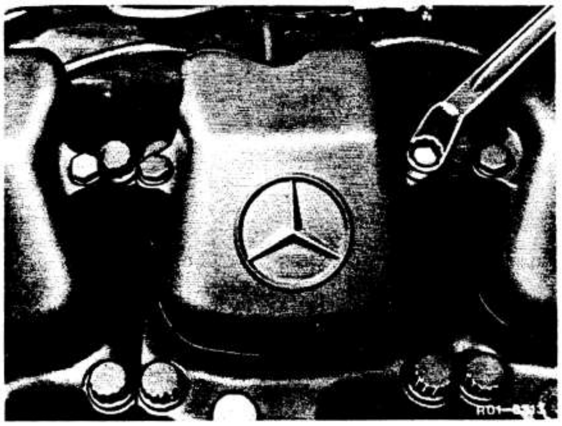
[1] Industrial engine

Special tools


407 589 00 63 00


001 589 53 21 00


363 589 02 21 00



Checking valve lift

1 Remove valve covers.

2 Mount engine cranking device.

3 Check valve clearance.

4 Set piston of the cylinder to be checked to ignition TDC.

5 Mount dial gauge holder. Set dial gauge under preload on the valve disc of the inlet valve and set scale to "0".

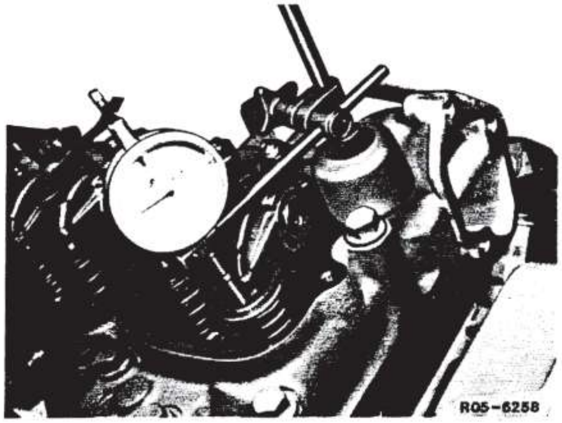
Note: Set maximum dial gauge preload of only 5 mm to ensure the measuring range is sufficient to cover the valve lift.

6 Crank engine in normal direction of rotation and observe dial gauge until the inlet valve has completely opened.

7 Read off measured value "valve lift inlet valve".

Dial gauge	001 589 53 21 00
Dial gauge holder	363 589 02 21 00

Note: Due to the saddle cams, the value must be obtained twice.



8 Once again set the piston of the cylinder to be checked to ignition TDC.

9 Set dial gauge under preload on the valve disc of the exhaust valve and set scale to "0".

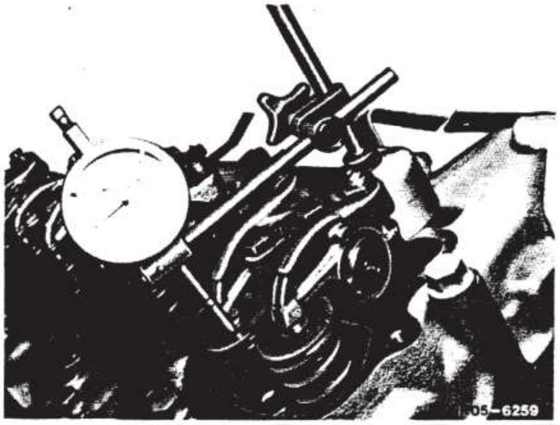
Note: Set maximum dial gauge preload to only 5 mm to ensure the measuring range covers the valve lift.

10 Crank engine in normal direction of rotation and observe dial gauge until the exhaust valve has completely opened.

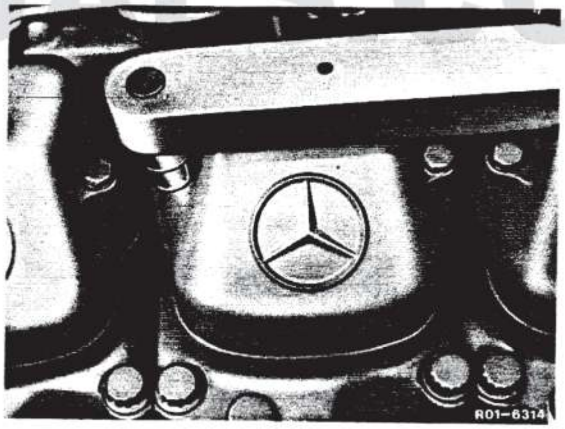
11 Read off measured value "valve lift exhaust valve".

Dial gauge	001 589 53 21 00
Dial gauge holder	363 589 02 21 00

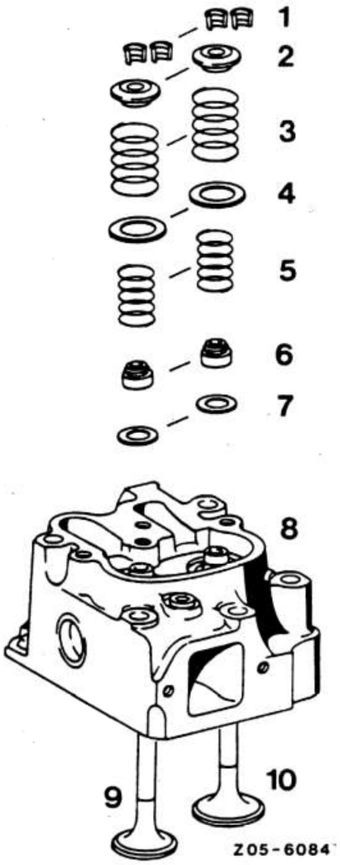
Note: Due to saddle clams, the value must be obtained twice.



12 Detach dial gauge with dial gauge holder. Remove cranking device and mount valve covers.



05 – 3133 Renewing Valve Springs



1 Valve collet
2 Spring plate
3 Outer valve spring
4 Washer
5 Inner valve spring
6 Valve stem seal...................................... Special tool 403 589 00 61 00
7 Washer
8 Cylinder head
9 Exhaust valve
10 Inlet valve

Valve springs

Engine type			Length at initial load mm (valve closed)	Load N	Length at final load mm (valve open)	Load N
441 442 443 441 LA 442 A 442 LA 443 LA	Inlet valve	Outer valve spring[1]	46,8	330 to 360	32,8	710 to 770
		Inner valve spring[1]	46,3	131 to 155	32,3	260 to 300
441.905 912 913 914 442.906 907 914 915 916 917 920 921 443.905	Exhaust valve	Outer valve spring[1]	46,8	330 to 360	32,8	710 to 770
		Inner valve spring[1]	46,3	131 to 155	32,3	260 to 300
441.906 907	Exhaust valve	Outer valve spring[1]	46,8	397 to 437	32,8	776 to 844
442.908 909		Inner valve spring[1]	46,3	183 to 207	32,3	330 to 370
441 LA 442 A 442 LA 443 LA	Exhaust valve	Outer valve spring	46,8	340 to 370	32,8	640 to 700
		Inner valve spring	46,3	183 to 207	32,3	330 to 370

[1] Install more compactly wound side in direction of cylinder head

Workshop equipment

Valve fixture

Spring test balance

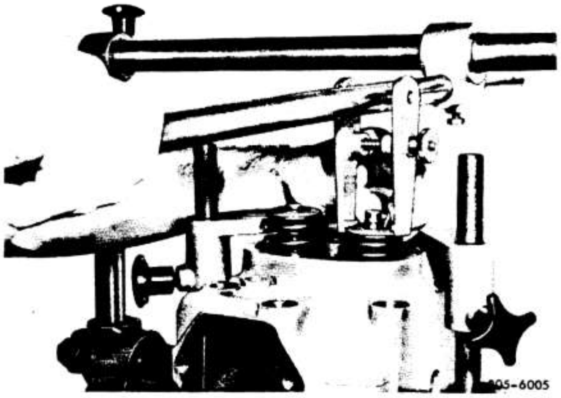
Removal

1 Place cylinder head on the space of the valve fixture and secure with clamps.

2 Set pressure arms to the diameter of the valve spring plate.

3 Insert rod in the lever boss and depress valve plate. Remove collet halves from the valve stem.

4 Release lever. Remove valve plate and valve springs.

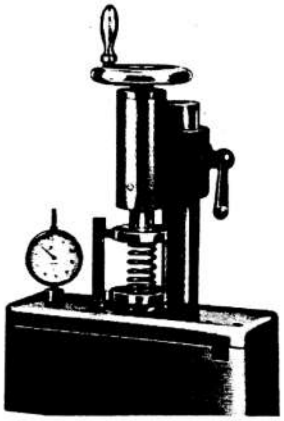


05-6005

Installation

1 Clean valve spring and check that the specified values are maintained on a spring balance.

2 Insert inner and outer valve springs and fit valve spring plate in position.

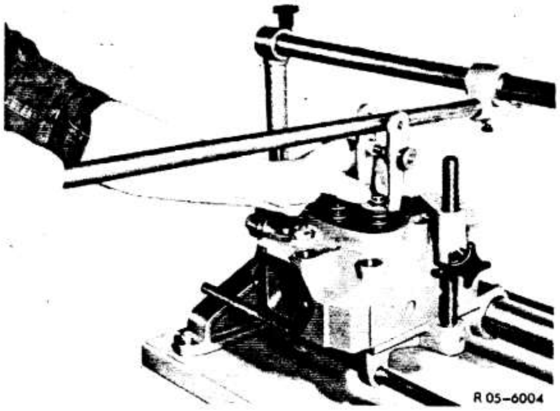


R 05/6385

3 Set pusher arms to the diameter of the valve spring plate.

4 Insert lever in the lever boss and depress valve spring plate. Insert collet halves in the groove of the valve stem. Slowly release lever while taking care that the valve springs fit correctly in the valve plate and that the valve collet halves fit correctly in the groove of the valve stem and in the valve plate.

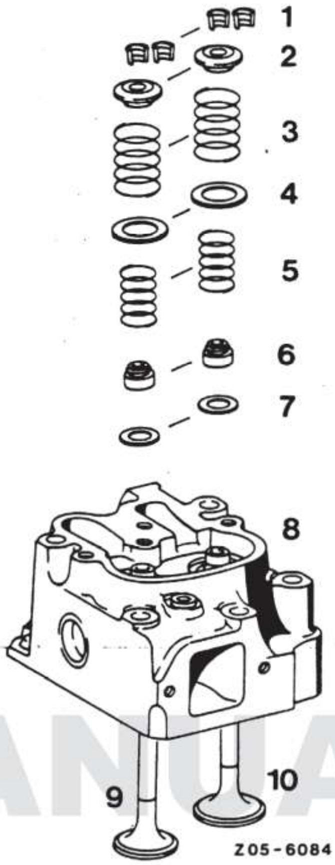
5 Remove valve spring fixture.



R 05-6004

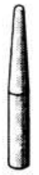
05 – 3514 Fitting Valve Stem Seals

Valves removed



1 Valve collet	
2 Spring plate	
3 Outer valve spring	
4 Washer	
5 Inner valve spring	
6 Valve stem seal	Special tool 403 589 00 61 00
7 Washer	
8 Cylinder head	
9 Exhaust valve	
10 Inlet valve	

Special tools



403 589 00 61 00

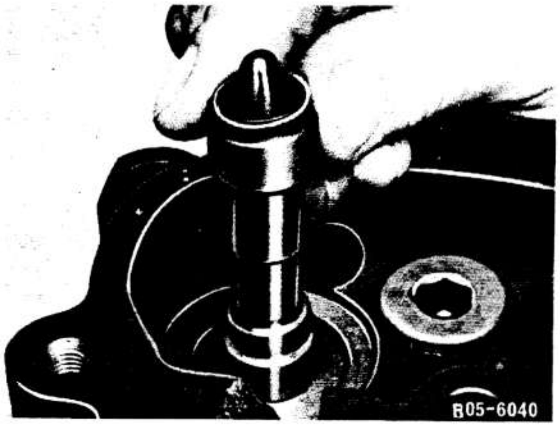
Fitting valve stem seal

1 Oil valve stems and insert in valve guides.

2 Firmly clamp cylinder head on the valve spring fixture.

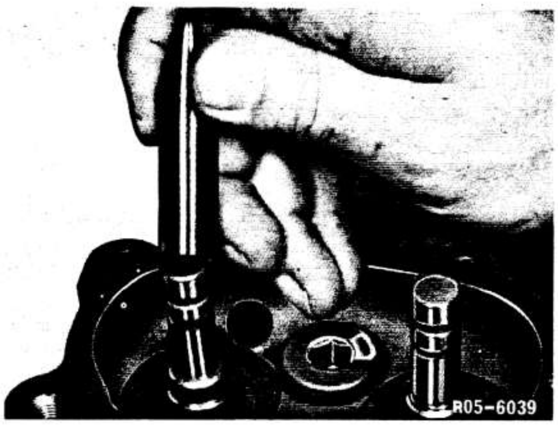
3 Fit mounting sleeve for valve stem seal on a valve.

Mounting sleeve 403 589 00 61 00

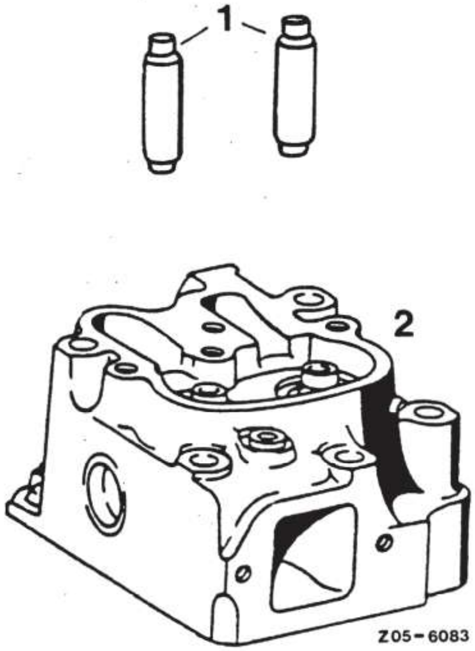


4 Press valve stem seal onto the valve guide.

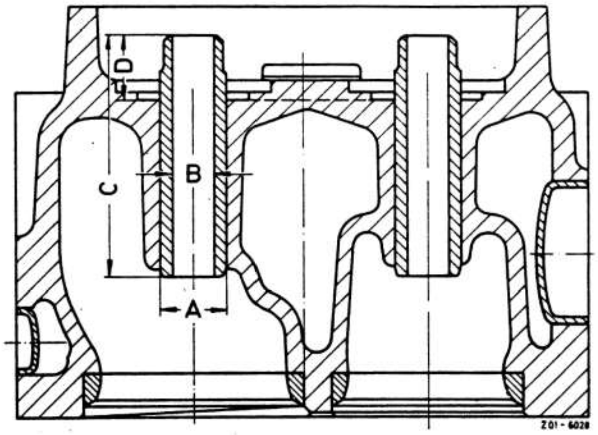
5 Remove mounting sleeve. Fit valve stem seal also on the second half.



Removal and Installation of Valve Guides



1 Valve guide	Special tool 403 589 00 15 00, 000 589 12 53 00, 000 589 17 53 00
2 Cylinder head	

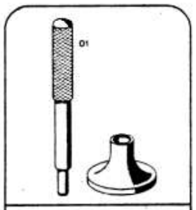


Data

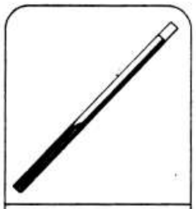
	Valve guide Ø		Length of valve guide dimension "C"		Bore hole in cylinder head dimension "A"		Overlap in cylinder head	Clearance of valve stem in the valve guide	
	Outside dimension "A" Inlet Exhaust	Inside dimension "B" Inlet Exhaust	Inlet	Exhaust	Inlet	Exhaust	Inlet Exhaust	Inlet	Exhaust
Standard	18,046 18,028	12,027 12,000	67		18,018 18,000		0,046 0,010	0,095 0,050	0,105 0,060
Oversize allow. 0.2	18,256 18,235				18,221 18,200		0,056 0,014		
Oversize allow. 0.4	18,456 18,435				18,421 18,400				

Projection of valve guide from spring base – upper edge Valve guide dimension "D"	17,5 17,1
Permissible center offset of valve seat with respect to valve guide	0,03

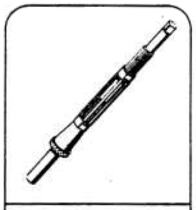
Special tools



403 589 00 15 00



000 589 12 53 00

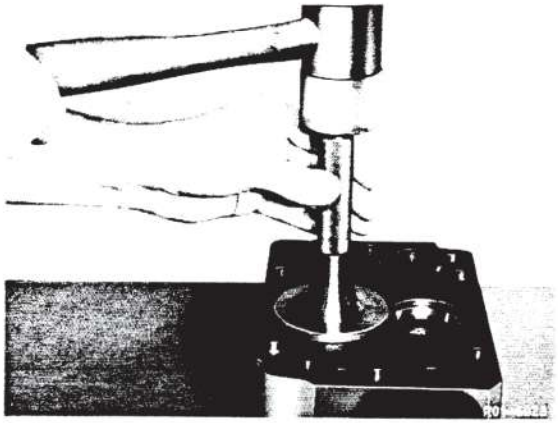


000 589 17 53 00

Removal and installationg

1 Clamp cylinder head.

2 Working from the combustion side, drive out the valve guides from the cylinder head using the special tool without spacer sleeve.



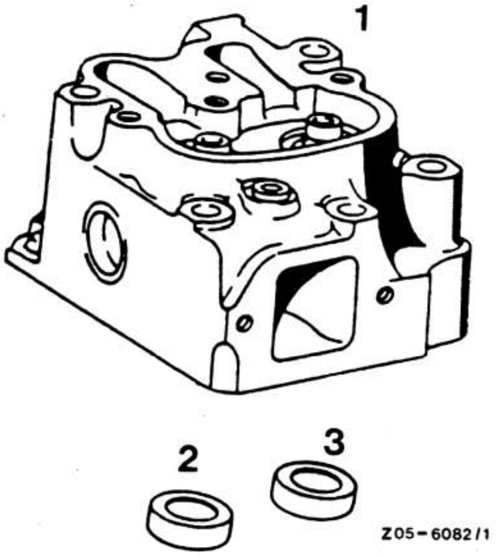
3 With an adjustable reamer, ream the bore in the cylinder head to the next largest oversize.

4 Coat new valve guide with graphite based oil and fit with special tool and the corresponding spacer sleeve.

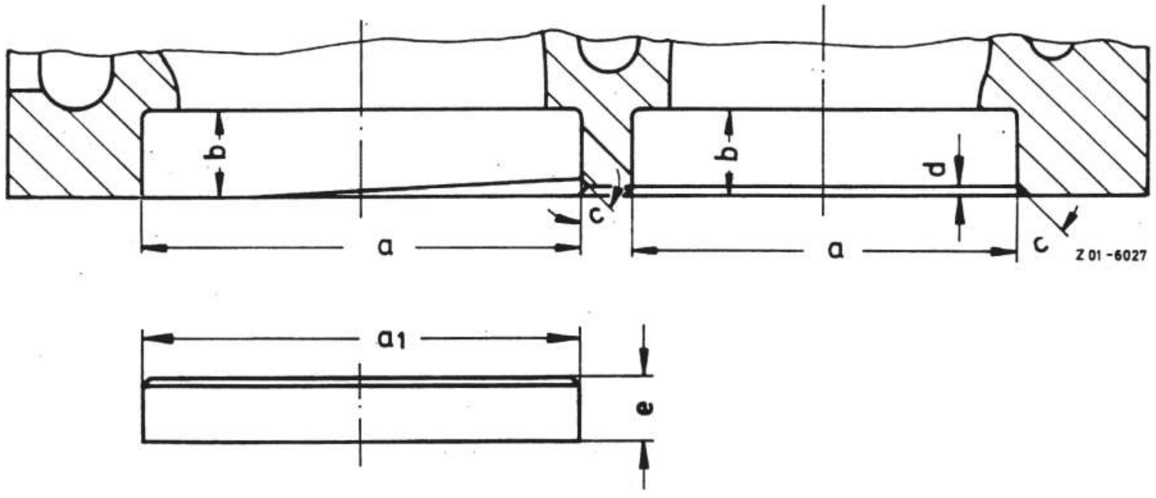
Drift	403 589 00 15 00
Reamer	000 589 17 53 00

5 Ream inside diameter of valve guide with reamer 000 589 12 53 00.

05 – 3832 Renewing Valve Seat Rings



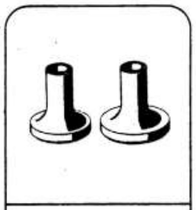
1 Cylinder head
2 Exhaust valve seat ring .... Special tool 000 589 29 33 00, 000 589 34 33 00
3 Inlet valve seat ring .... Special tool 000 589 30 33 00, 000 589 35 33 00



Data

		Inlet valve seat ring			Exhaust valve seat ring		
		Standard allowance	Oversize allowance 0,2	Oversize 0,4	Standard allowance	Oversize allowance 0,2	Oversize 0,4
Basic bore "a" in cylinder head		$\frac{60.030}{60.000}$	$\frac{60.230}{60.200}$	$\frac{60.430}{60.400}$	$\frac{53.030}{53.000}$	$\frac{53.230}{53.200}$	$\frac{53.430}{53.400}$
Outside diameter of valve seat ring "a1"		$\frac{60.11}{60.10}$	$\frac{60.31}{60,30}$	$\frac{60.51}{60.50}$	$\frac{53.11}{53.10}$	$\frac{53.31}{53.30}$	$\frac{53.51}{53.50}$
Overlap of valve seat ring in cylinder head		0.07–0.11			0.07–0.11		
Depth "b" of bore in cylinder head		$\frac{12.6}{12.5}$	$\frac{12.8}{12.7}$	$\frac{13.0}{12.9}$	$\frac{12.6}{12.5}$	$\frac{12.8}{12.7}$	$\frac{13.0}{12.9}$
Height "e" of valve seat ring	441 442 443	$\frac{8.9}{8.8}$	$\frac{9.1}{9.0}$	$\frac{9.3}{9.2}$	$\frac{9.7}{9.6}$	$\frac{9.9}{9.8}$	$\frac{10.1}{10.0}$
Distance between mating surface cylinder head and face of valve seat ring		$\frac{3.8}{3,6}$			$\frac{3.0}{2,8}$		
Height "e" of valve seat ring	441 LA 442 A 442 LA 443 LA	$\frac{8.4}{8.3}$	$\frac{8.6}{8.5}$	$\frac{8.8}{8.7}$	$\frac{9.2}{9.1}$	$\frac{9.4}{9.3}$	$\frac{9.6}{9.5}$
Distance between mating surface cylinder head and face of valve seat ring		$\frac{4.3}{4,1}$			$\frac{3.5}{3,3}$		
Chamfer "c"		–			45°		
Depth "d" of chamfer		–			$\frac{1.8}{1.6}$		

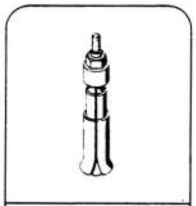
Special tools



403 589 01 15 00

403 589 00 15 01

001 589 53 21 00



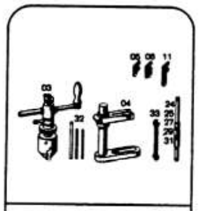
000 589 29 33 00

000 589 30 33 00

000 589 34 33 00

000 589 35 33 00

346 589 00 63 00



000 589 16 69 00

Workshop equipment

Internal measuring instrument

Valve fixture

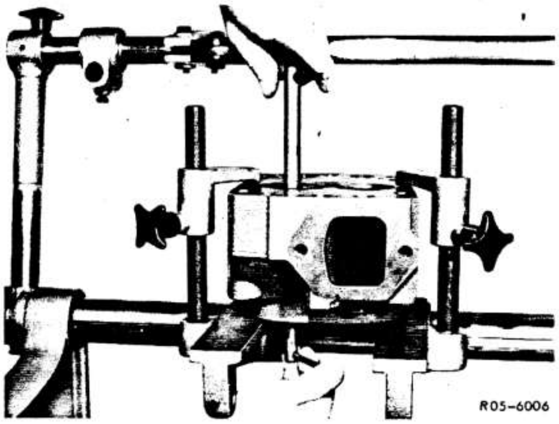
Removal

Note: Valve guides are installed.

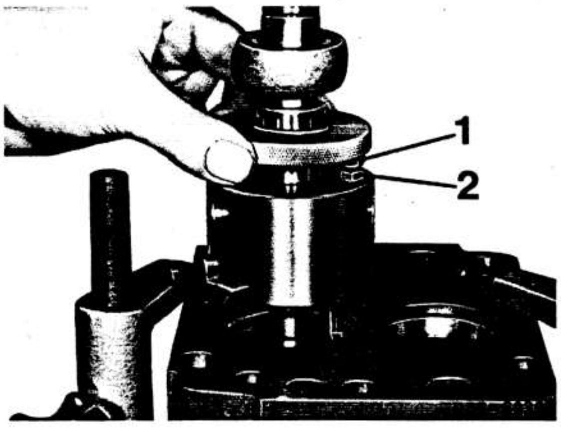
1 Clamp cylinder head on the valve fixture.

2 Insert pilot (11.9 mm ∅) in the valve guides until the limit stop of the slotted rod rests on the valve guide, if necessary press slotted rod downwards with the aid of a screwdriver. Tighten with the pin inserted in the top and bottom of the pilots.

3 Clamp tool for ring groove in the holder.

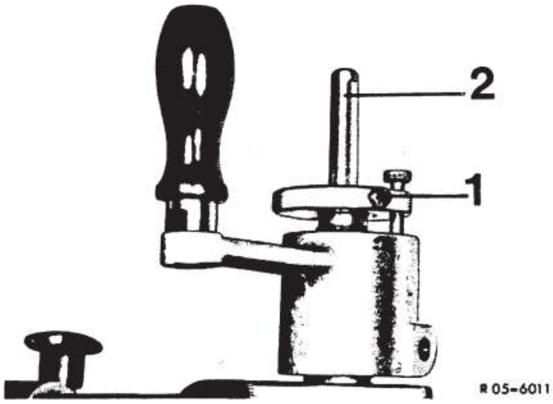


4 Loosen lock nut (2). Place turning tool over the pilots coated with oil, turn screw (1, quick adjustment) until the cutting tool rests on the pilot then slide the turning tool downwards until the cutting tool is positioned in the center of the valve seat ring.



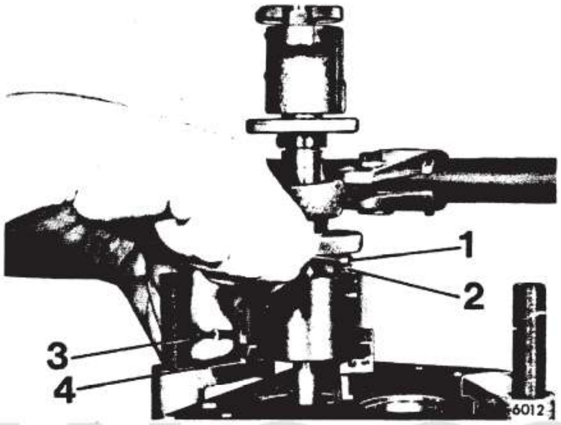
5 Firmly hold turning tool in this position. Loosen lock screw (1) of the pilot support, press pilot support (2) down until it rests on the pilot. Retighten lock screw (1).

6 Set stay bar with hand crank in suitable position with respect to the workpiece. Firmly clamp pendulum guide horizontally approx. in the center of the guide with the stay clamp. The turning tool must turn as easily as it did previously.



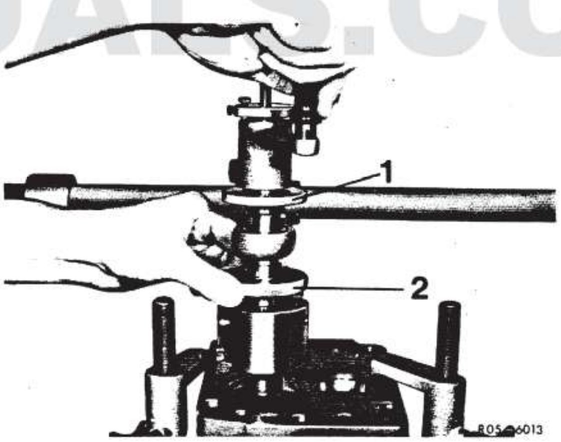
7 Turn back screw for the fast adjustment (1) until the cutting tool approaches the valve seat ring but still makes no contact. Firmly tighten lock nut (2). Screw in horizontal stop screw (3) until it comes up against the housing and then turn back by 2 to 3 mm. Tighten the clamping screw (4) below it.

8 Set the height of the cutting tool such that, after machining, **approx. 1 mm** of material remains at the bottom of the valve seat ring.



Note: By firmly holding the knurled disc (1), and turning the crank of the turning tool in clockwise direction, the cutting tool moves downwards or the cutting tool moves upwards when the crank is turned in counterclockwise direction.

9 Cut ring groove in the valve seat ring by turning the turning tool while firmly holding the knurled disc "2" which must be temporarily released if the turning resistance increases. Steps of ring groove approx. 2–3 mm.



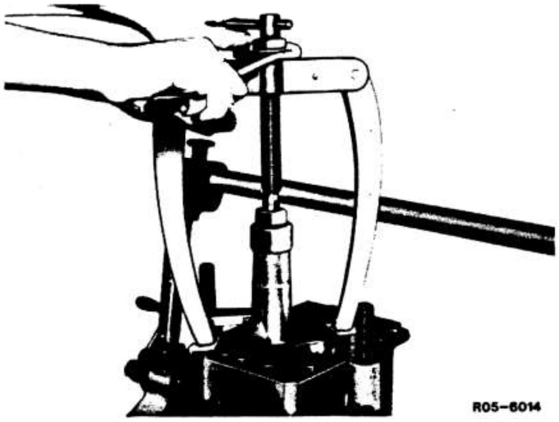
Note: Keep feed low. The turning tool must always turn easily. This is ensured by temporarily releasing the knurled disc (2).

10 Detach turning tool.

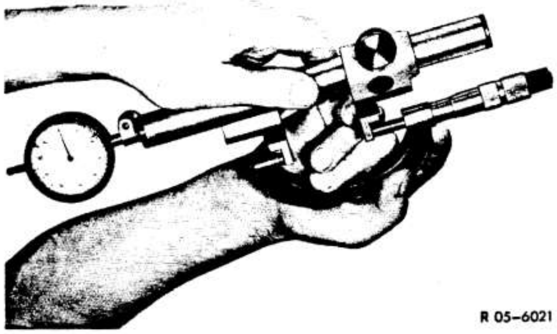
11 Fit internal extractor for inlet or exhaust in the ring groove, tighten nut and withdraw valve seat ring countersupport.

Note: Copper plates must be placed under the contact surface of the countersupport in order to prevent damage to the surface of the cylinder head.

Internal extractor	000 589 30 33 00
Internal extractor	000 589 29 33 00
Countersupport	000 589 35 33 00
Countersupport	000 589 34 33 00

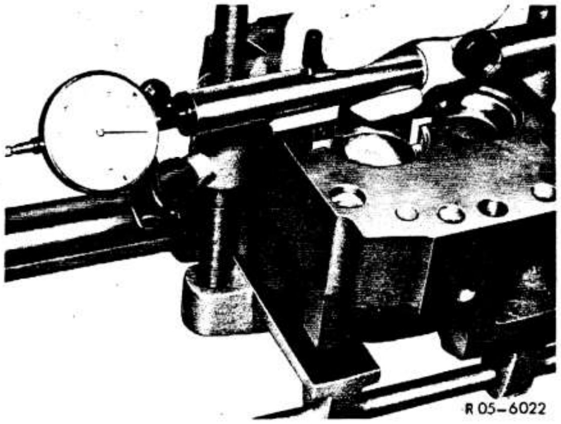

R05-6014

12 Set internal measuring instrument with micrometer.


R 05-6021

13 Measure the bores for the valve seat rings in the cylinder head with the internal measuring instrument.

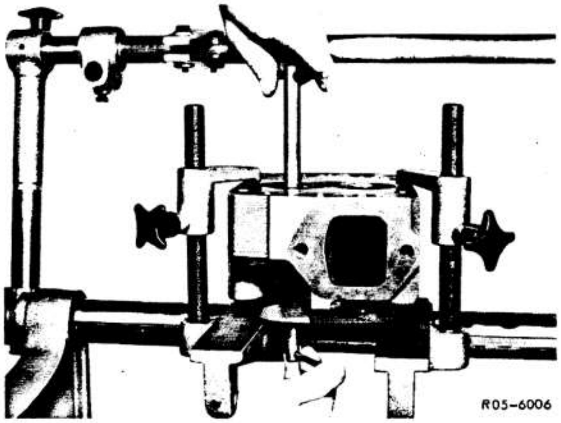
Note: If the measured values deviate from the values specified in the table, the bore holes must be bored to the next oversize.


R 05-6022

Remachining basic bore

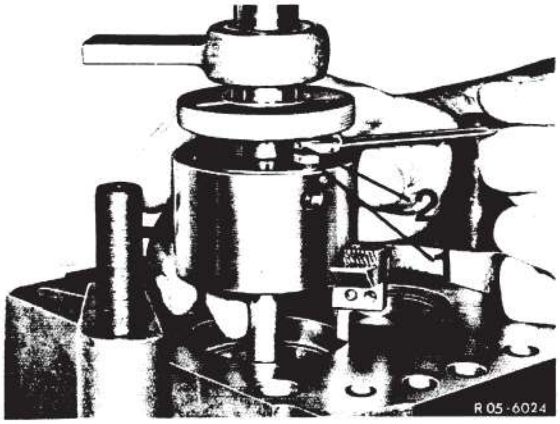
1 Clamp cutting tool in holder.

2 Insert pilot (11.9 mm ∅) in the valve guide until the stop of the slotted rod rests on the valve guide, if necessary press down slotted rod with the aid of a screwdriver. Firmly tighten with the pin inserted at the top and bottom of the pilot.

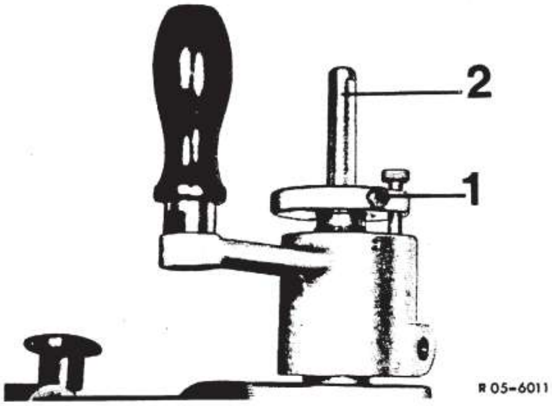

R05-6006

3 Loosen lock nut (1), slide cutting tool over the pilots coated with oil, turn quick adjustment screw (2) until the cutting tool has moved horizontally over the hole. The slide the turning tool down until the cutting tool rests on the cylinder head.

Caution: Carefully lower the tool to ensure the tungsten carbide cutting bit of the tool is not damaged.

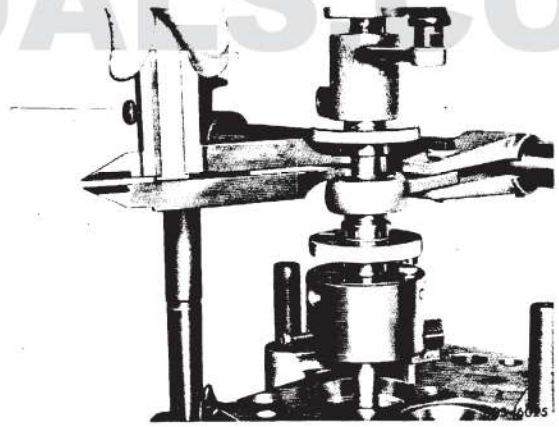


4 Loosen lock screw (1), press down pilot support (2) until it rests on the pilot, retighten lock screw.



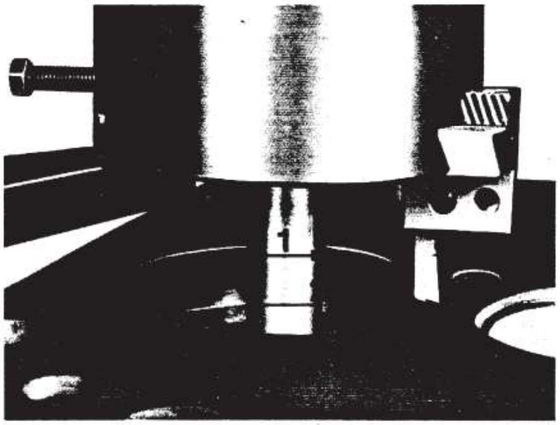
5 By turning the knurled disc, set the height of the cutting tool such that it is such clear.

6 Firmly clamp pendulum guide horizontally with the stay clamp. The working depth (table dimension "b") must be set between the adjusting ring and pendulum guide.



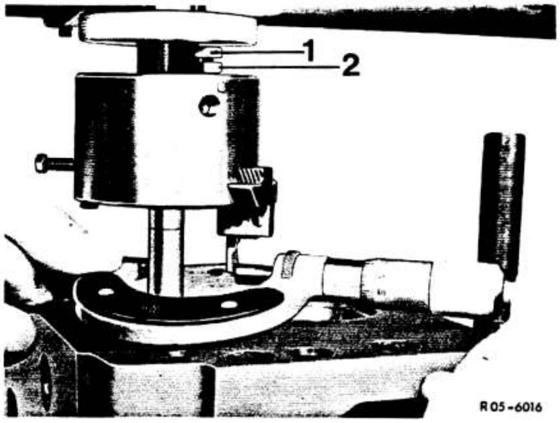
7 Calculation of setting "2": The setting "2" is derived from the basic bore "a" (table column "a") and the pilot diameter "1" divided by 2.

$$"2" = \frac{a + 1}{2}$$

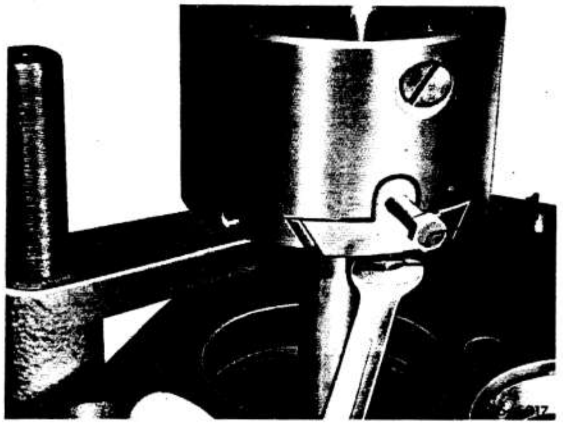


8 Loosen coupling nut, set micrometer to dimension "2", slightly raise turning tool, place micrometer on pilot, precisely set cutting tool to size "2" with the quick adjustment (1). Firmly tighten coupling nut (2).

Note: It is advisable to set the cutting tool 0.1 mm smaller in ⌀ for first cut.

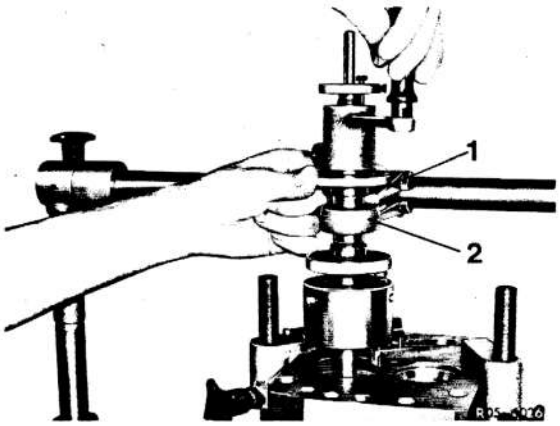


9 Screw in horizontal stop screw (1) until it rests on the housing. Tighten clamping screw (2) beneath it to ensure the stop screw cannot turn.



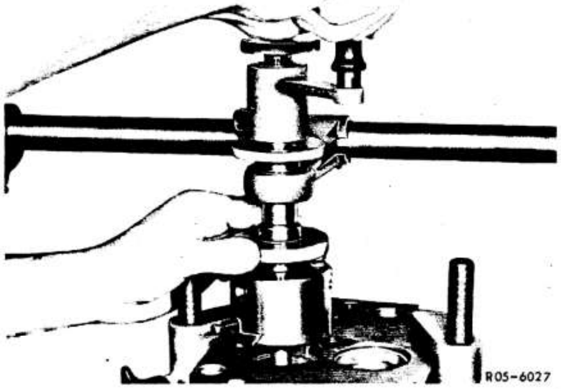
10 By turning the hand crank while at the same time firmly holding the upper knurled disc for vertical feed, bore the hole for the valve seat ring until the adjusting ring (1) comes to rest on the stay bearing mount (2).

Note: Readjust the cutting tool as often as necessary until the size calculated in step 7 is reached and then turn without applying feed in order to achieve a peak-to-valley height (surface smoothness) of max. 0.006 mm.

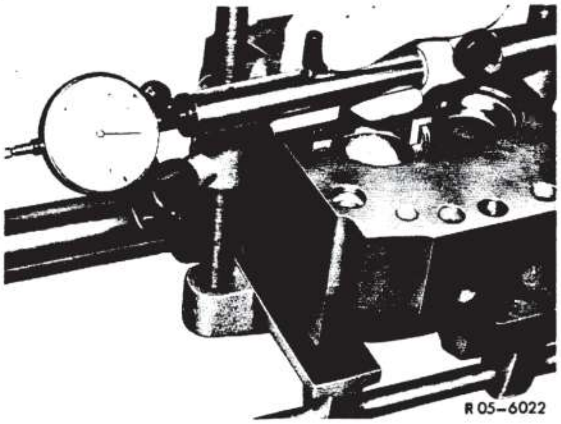


11 Loosen coupling nut, turn back cutting tool with quick adjusting screw while slightly lifting the turning tool.

12 By turning the hand crank while at the same time firmly holding the bottom knurled disc for horizontal feed, turn the end face until the stop screw rests on the housing.



13 Detach turning tool, measure bore hole. **There must be an overlap of 0.07–0.11 mm between the valve seat ring and bore hole.**


R 05–6022

Installation

1 Place valve seat rings in supercooling box and fill with liquid nitrogen. Supercool valve seat rings for approx. 20 to 30 minutes.

Note: Liquid nitrogen can be obtained from any oxygen manufacturer.

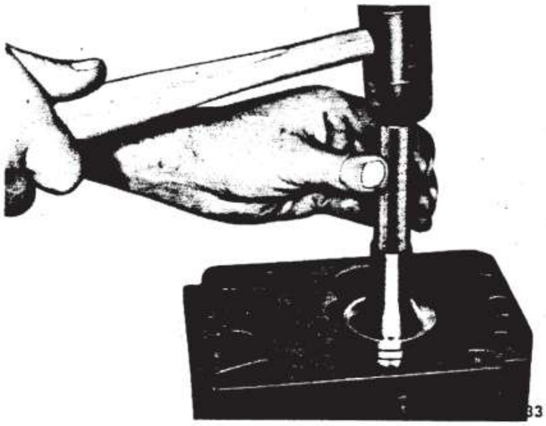
2 Heat cylinder head in water bath to a temperature of approx. 80° C.

3 Using pliers, remove valve seat ring from the supercooling box and place on the bore hole of the heated cylinder head.

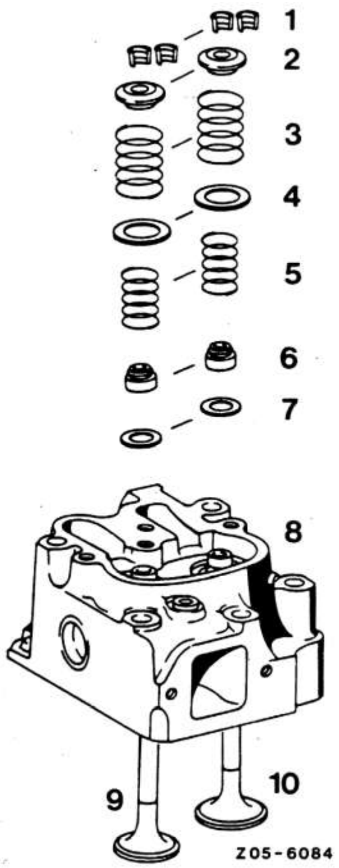
R05–6034

4 Drive in valve seat ring with special tool.

Installation sleeve	403 589 01 15 00
Drift	403 589 00 15 00


33

05 – 4102 Removal and Installation of Valves


1
2
3
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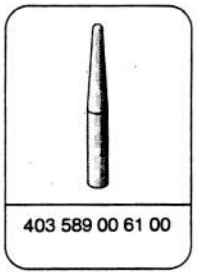
8
9
10
Z05-6084

1 Valve collet
2 Spring plate
3 Outer valve spring
4 Washer
5 Inner valve spring
6 Valve stem seal.................................... Special tool 403 589 00 61 00
7 Washer
8 Cylinder head
9 Exhaust valve
10 Inlet valve

Special tools


403 589 00 61 00

Valve fixture

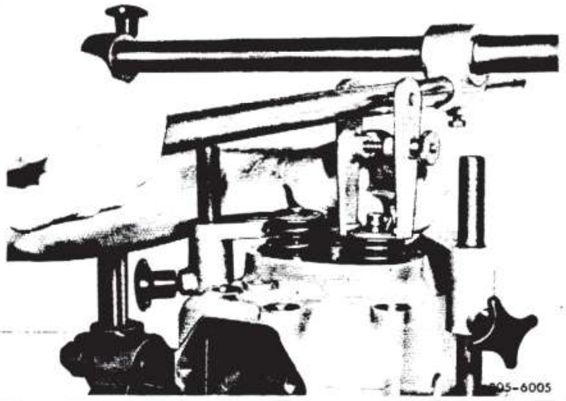
Removal

1 Place cylinder head on base of valve fixture and secure with clamps.

2 Set pusher arms to the diameter of the valve spring plate.

3 Insert lever in the lever boss and press spring plate. Remove valve collet halves from the valve stem.

4 Release lever. Remove valve spring plate and valve springs.



5 Remove valve stem seals from the valve guides.

6 Remove cylinder head from valve fixture and remove valves.

7 Remove shims for valve springs.

Installation

1 Oil valve stems and insert in valve guides.

2 Firmly clamp cylinder head on valve fixture.

3 Fit shims for valve springs.

4 Mount valve stem seals.

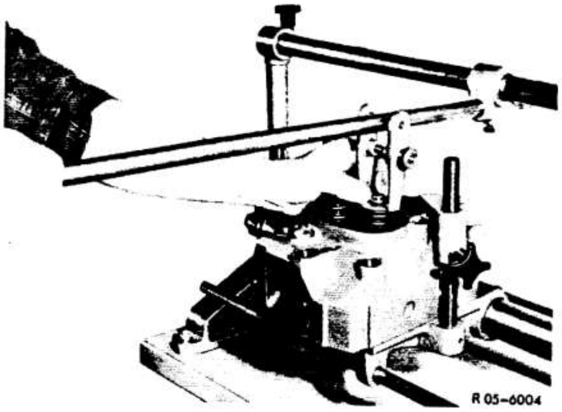
5 Fit valve springs and valve spring plate.

Mounting sleeve 403 589 00 61 00

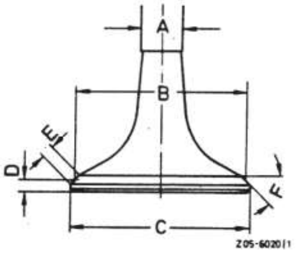
6 Set pusher arms to the diameter of the valve spring plate.

7 Insert lever in lever boss and depress valve spring plate. Insert valve collets in the groove of the valve stem. Slowly release lever while taking care to ensure that the valve springs fit correctly in the valve spring plate and the valve collet halves fit correctly in the groove of the valve stem and in the valve spring plate.

8 Remove valve fixture.



05 – 4202 Grinding Valves



Data

Valve seat angle "F"	Valve head ∅ "C"	Stem ∅ "A"	Length of valve	∅ "B"	Height D when new	Machining limit	Valve seat width E	Machining limit	Hardness at end of valve stem
Inlet 30°	$\frac{58.8}{59.0}$	$\frac{11.950}{11.932}$	$\frac{142.7}{142.3}$	$\frac{54.99}{55.01}$	$\frac{3.6}{3.8}$	3.3	$\frac{4.5}{5.5}$	6.5	HRC $\frac{54}{60}$
Exhaust 45°	$\frac{50.9}{51.1}$	$\frac{11.940}{11.922}$	$\frac{142.7}{142.3}$	$\frac{47.99}{48.01}$	$\frac{3.0}{3.2}$	2.7	$\frac{4.5}{5.5}$	6.5	HRC $\frac{54}{60}$

Permissible run-out between valve seat and stem	0.03
Permissible run-out between valve head and stem	0.20
Permissible out-of-round of valve seat	0.01

Grinding valves

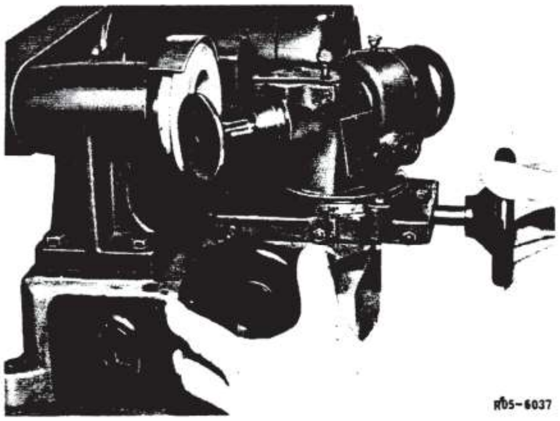
1 Clean removed valves, remove stubborn oil carbon deposits.

2 Check valves to ensure they can be reused. There must be no surface damage on the ends of the valve stems. The grooves for the valve collets must not be chipped and the chrome layer on the valve stems must be complete. Charred valves must always be renewed.

3 Check valves for concentricity and dimensional accuracy. Valves must never be straightened.

4 Slight deviations in concentricity can be corrected by regrinding the valve seat on a valve grinding machine.

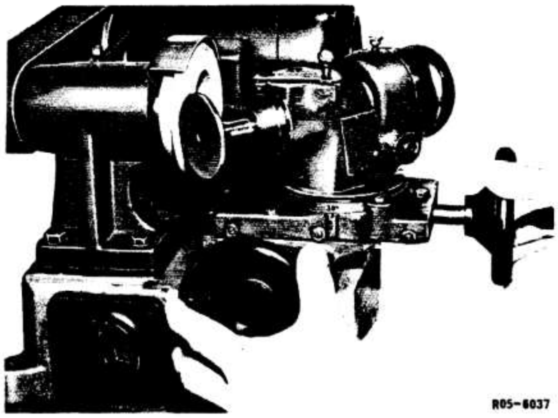
5 It is advisable to clamp the valve just behind the valve head in order to avoid undesirable vibrations.



6 Set grinding angle on the scale.

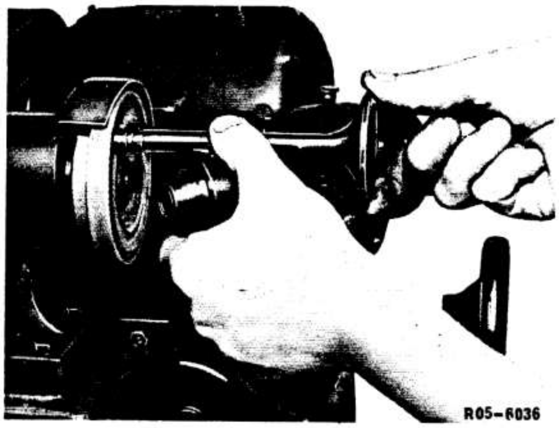
7 Slowly move the valve with advance feed towards the running grinding wheel until it comes in contact with the seat surface of the valve.

8 Grind with small feed until the valve seat is clean over its entire circumference.


R05-6037

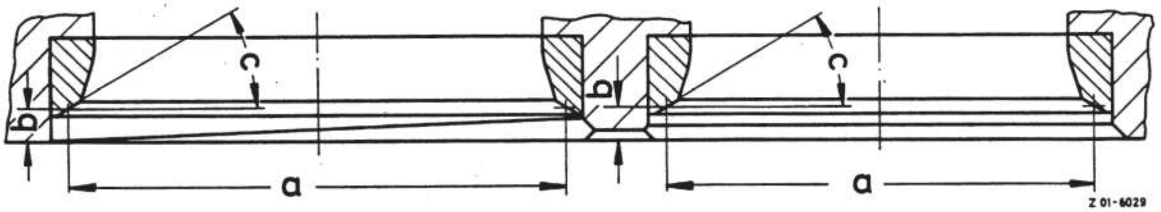
Note: After this procedure, the dimension "D" must not be below the size specified in the table.

9 The end of the valve stem can be face ground on the V-support attached to the valve grinding machine.


R05-6036

05 – 4532 Remachining Valve Seats

Valve guides installed



Data

Engine		441 442 443	441 LA 442 A, LA 443 LA 444 A1), LA1)
Valve seat angle "c"	Inlet	30°	30°
	Exhaust	45°	45°
Diameter "a"	Inlet	56.99 57.01	54.99 55.01
	Exhaust	48.99 49.01	47.99 48.01
Check size "b"	Inlet	3.9 + 0.15	4.5 + 0.15
	Exhaust	3.4 + 0.15	3.9 + 0.15
Distance between mating surface of cylinder head and end face of valve head	Inlet	0.7 + 0.4	0.7 + 0.4
	Exhaust	0.7 + 0.4	0.7 + 0.4

1) Industrial engine

Note:
Under no circumstances must the lower edge of the valve seat at the valve come in contact with the valve seat in the cylinder head otherwise the edge will work into the seat, thus causing the valve to leak and scorch. The valve seat must therefore be corrected at this point such that the lower edge of the valve is clear.

Special tools

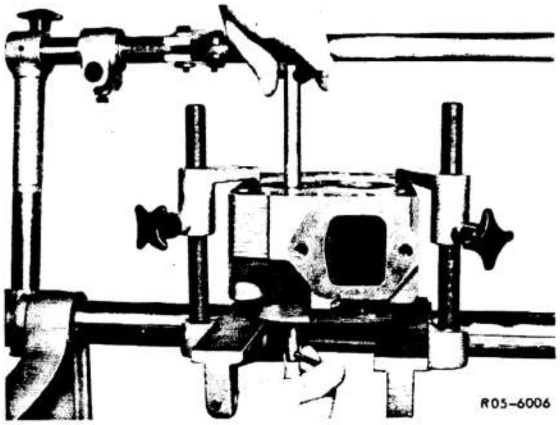
000 589 16 69 00

Workshop equipment

	Order No.	**Supplier**
Valve seat tester	217.93.601	Ludwig Hunger Postfach 700960 D 8000 München 70

Permissible deviation in concentricity of the valve seat with respect to the valve guide	0.01
Measured at inlet at ∅ 55/57 exhaust at ∅ 48/49	

Remachining valve seats



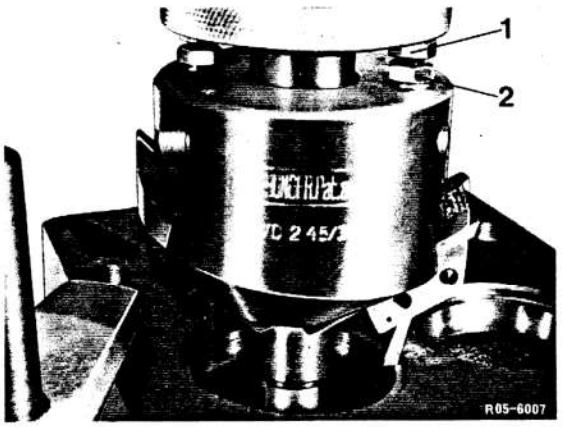
Note: Valve guides are installed.

1 Clamp cylinder head on valve fixture.

2 Measure valve seat diameter.

Note: In the case of only slightly pitted valve seats, remachining can take place without renewing the valve seat rings provided the machining limit see table dimension "a") is not exceeded.

3 Insert pilot (11.9 mm ∅) in the valve guide until the stop of the slotted rod rests on the valve guide, if necessary press down the slotted rod with the aid of a screwdriver. Firmly tighten pilot.

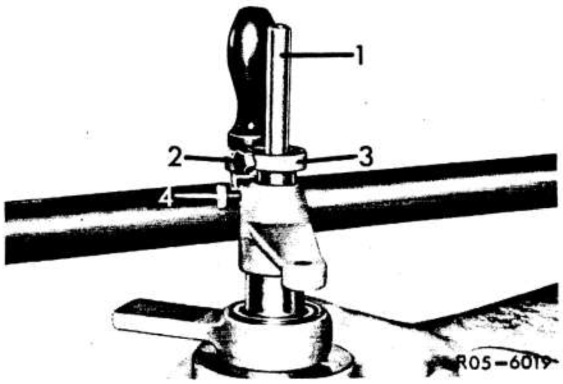


4 Firmly tighten cutting tool in the holder.

Note: Take particular care to ensure that the cutting tool is set straight in the holder. Deactivate free holder by loosening the coupling nut. Mount crank handle on the arm marked with 30° or with 45° in the case of 45° valve seat rings.

5 Loosen coupling nut (2), slide the cutting tool over the pilot and by turning the screw (1) move the quick adjustment such that the cutting tool is positioned in the center of the valve seat.

1 Quick adjustment
2 Coupling nut for holder

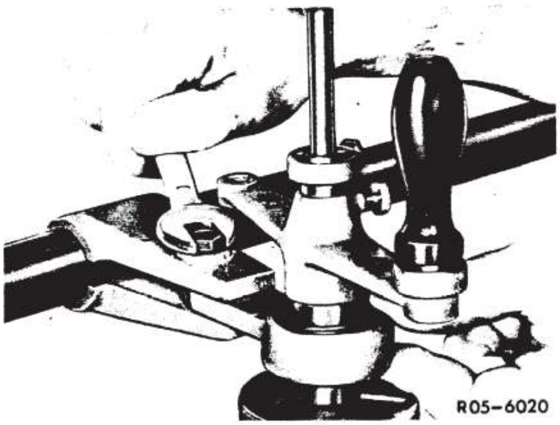


6 Press down pilot support (1) onto the pilot and firmly clamp with the aid of the screw (2) by screwing down the knurled disc (3) and firmly tightening the lock screw (4).

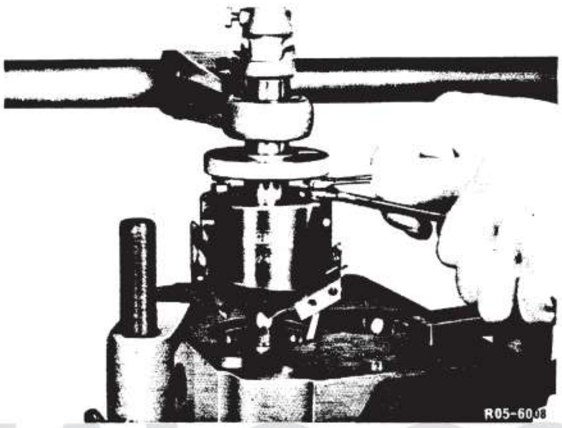
1 Pilot support
2 Lock screw of pilot support
3 Knurled disc for feed
4 Lock screw

7 Set stay bar with crank handle in correct position. Firmly clamp pendulum guide horizontally approximately in the center of the guide with the stay clamp.

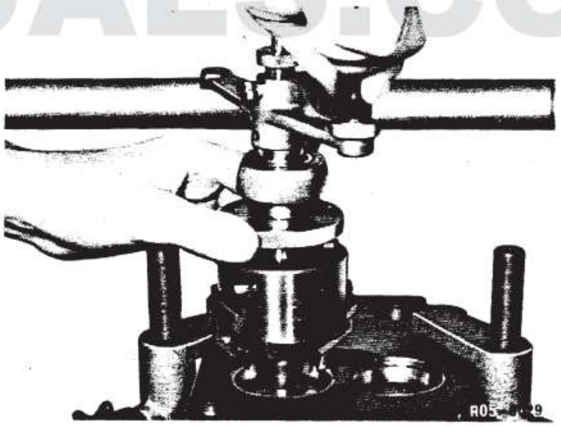
The turning tool must now turn just as easily as it did before.



8 By turning the quick adjustment, move cutting tool next to the inner seat edge then tighten the coupling nut. Still do not apply feed at this point.



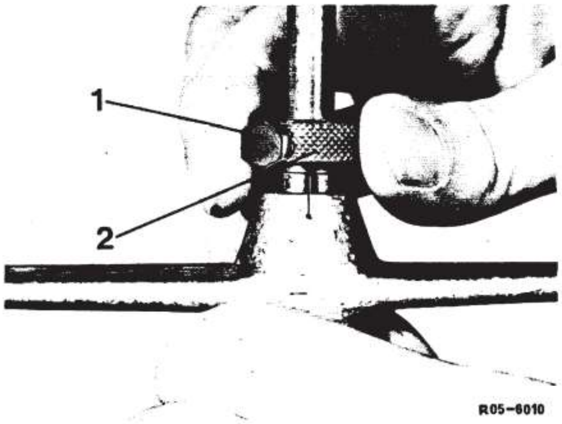
9 Firmly hold feed disc and turn the crank. In the majority of cases, this results in irregular stock removal. After turning, release the coupling nut of the quick adjustment and once again move the cutting tool to the side.



10 Loosen lock screw (1) and turn the knurled disc (2) approx. ½ to 2 graduations (1 graduation = 0.1 mm) to the left. Retighten lock screw (1) and coupling nut before turning the crank.

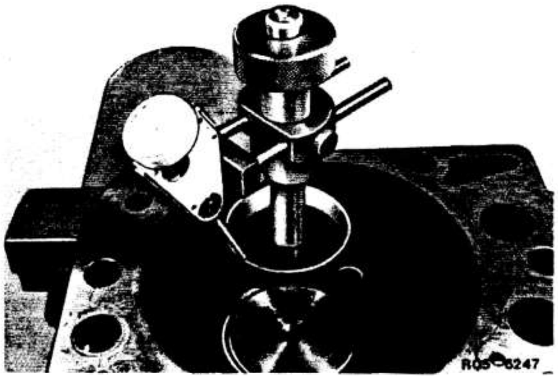
11 Firmly hold feed control and turn crank until the tip of the cutting tool moves out.

1 Lock screw
2 Knurled disc for feed



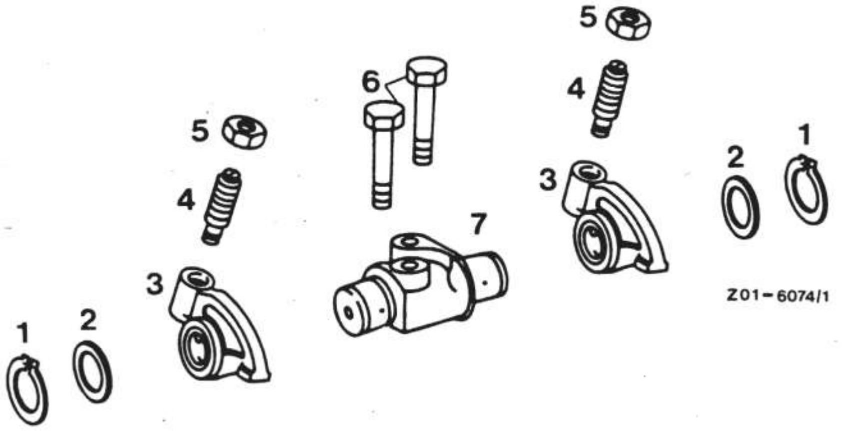
12 The feed must be applied as often as necessary to clean the seat (the machining limit must not be exceeded). Then turn the tool through once again without feed. The values specified in the table must be reached for newly installed valve seat rings.

13 Check concentricity deviation of the valve seat with respect to the valve guide.



05 – 5542 Renewing Rocker Arms

Rocker arm removed



1	Retaining ring	
2	Washer	
3	Rocker arm	
4	Valve adjusting screw	
5	Lock nut	
6	Bolt	75 Nm
7	Rocker arm bracket	

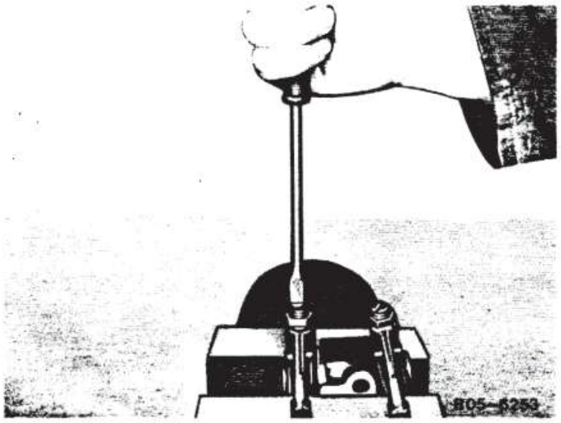
Data

Inside diameter of rocker arm bush when installed	25.021 25.005
Diameter of shaft of rocker arm bracket	24.980 24.967

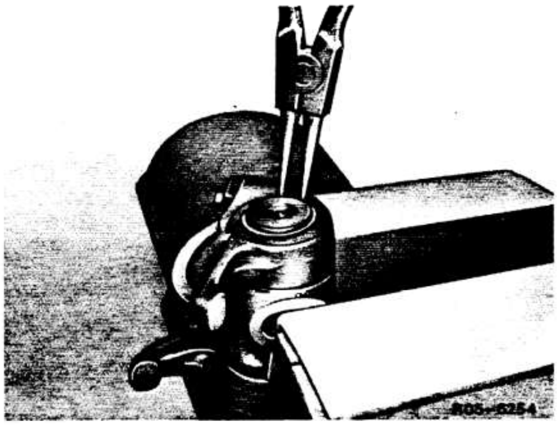
Removal

1 Clamp rocker arm bracket in vice (use soft jaw guards).

2 Loosen lock nut of valve adjusting screw and unscrew valve adjusting screw.

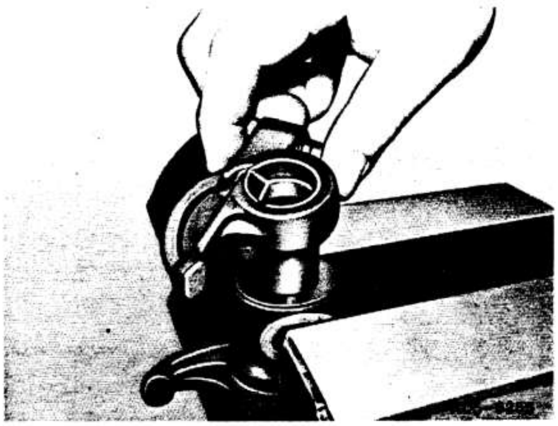


3 Remove rocker arm retaining ring.



4 Remove washer and rocker arm.

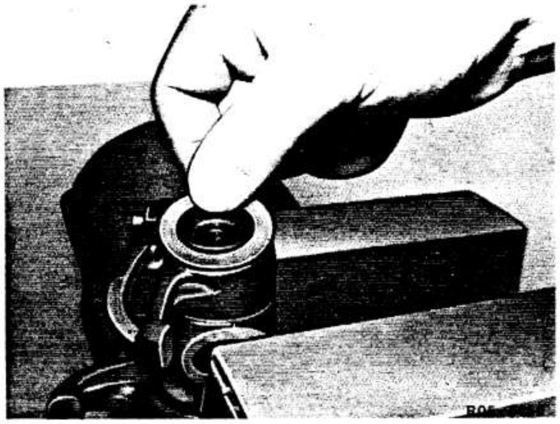
5 Thoroughly clean all parts and check for wear.



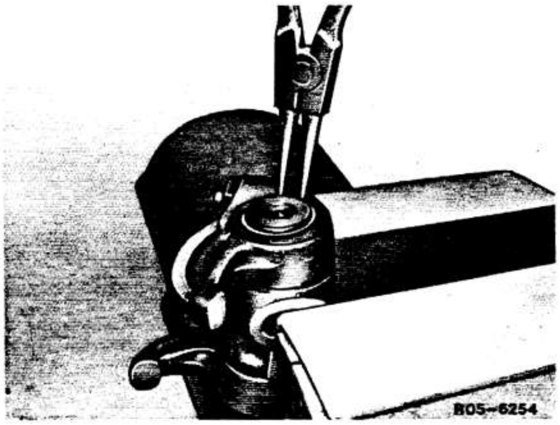
Installation

Note: The rocker arm brackets are supplied ex factory with fitted balls and the rocker arms with bushes ready to be installed.

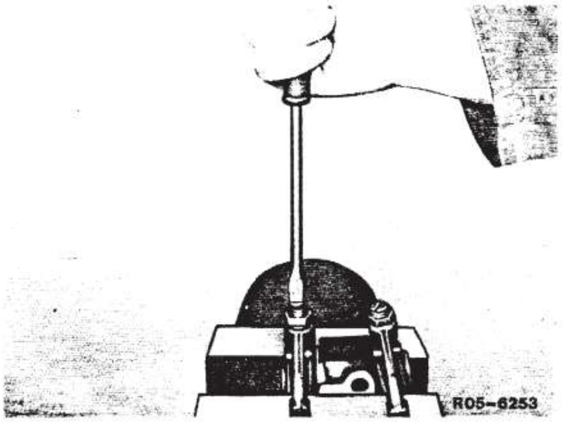
1 Mount rocker arm and washer on rocker arm bracket.



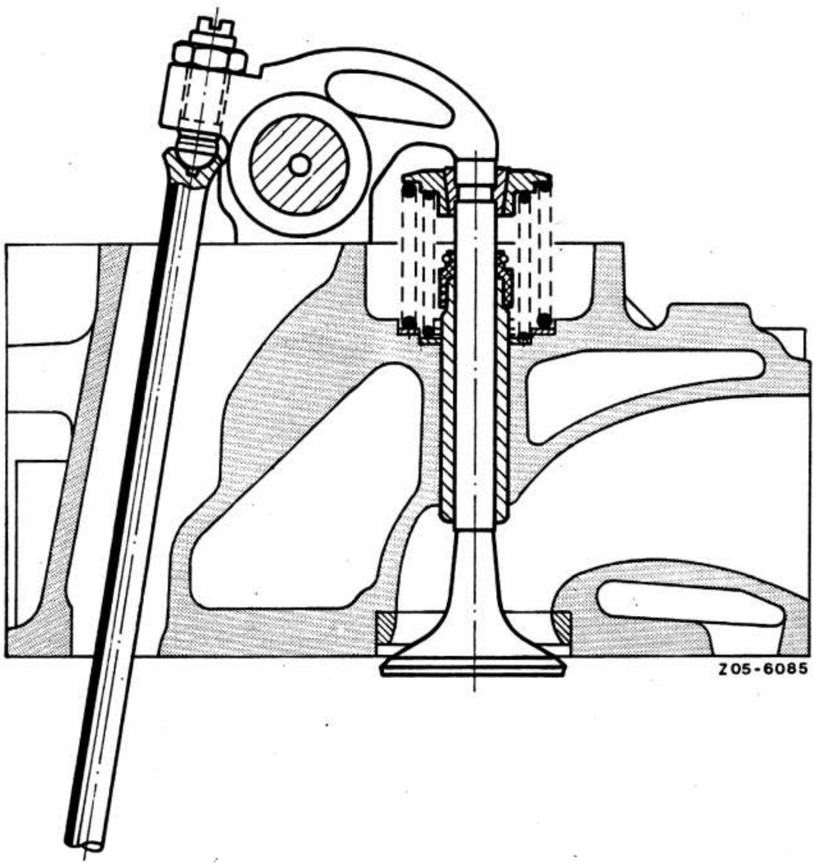
2 Fit retaining ring for rocker arm.



3 Screw in valve adjusting screw together with lock nut in the rocker arm.



05 – 6010 Checking Timing by Way of Valve Lift



Data

Engine		441 442 443	441 LA 442 A, LA 443 LA 444 A[1], LA[1]
Valve lift when valve set with no clearance	TDC inlet	$\frac{0.60}{0.80}$	$\frac{0.55}{0.75}$
	TDC exhaust	$\frac{0.65}{0.85}$	$\frac{0.65}{0.85}$
Timing at specified valve clearance	Inlet opens before TDC	16°	17°
	Inlet closes after BDC	42°	29°
	Exhaust opens before BDC	57°	71°
	Exhaust closes after TDC	13°	13°

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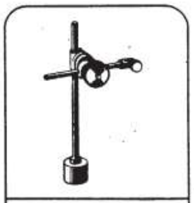
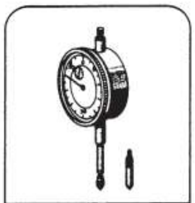
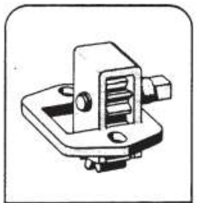
[1] Industrial engine

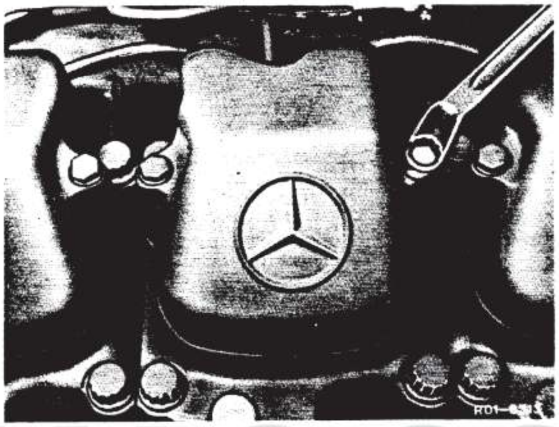
Special tools


363 589 02 21 00


001 589 53 21 00


407 589 00 63 00

Checking timing

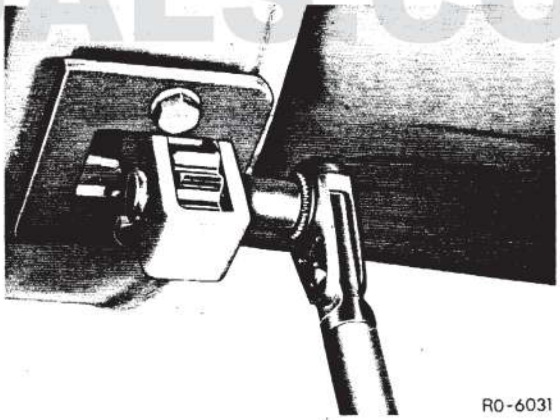


1 Remove valve covers of the first and synchronously running cylinder.

2 ,Mount engine cranking device.

3 Set piston of cylinder No. 1 to the TDC marking in ignition TDC.

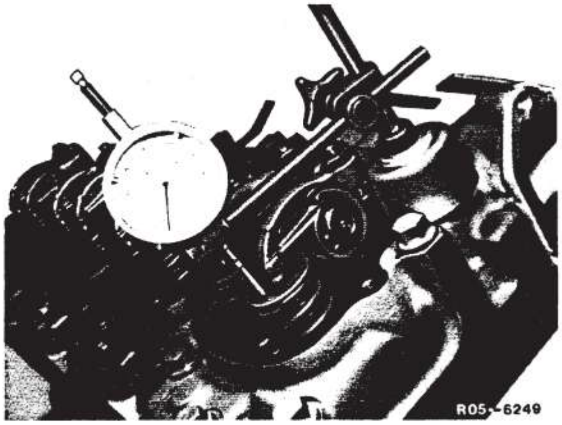
Note: The piston of the synchronously running cylinder is therefore in the overlap TDC position.


R0-6031

4 Take up valve clearance of cylinder No. 1.

5 Crank engine in normal direction of rotation by one turn until the exact TDC setting is obtained at the flywheel.

Note: The piston of cylinder No. 1 is therefore in overlap TDC.



6 Mount dial gauge holder on cylinder head.

7 Set dial gauge under preload on the valve spring plate of the inlet valve and set scale to "0".

8 Turn back engine and observe dial gauge until the pointer of the dial gauge stops.

9 Read off measured value TDC inlet.

Dial gauge	001 589 53 21 00
Dial gauge holder	363 589 02 21 00

10 Remove dial gauge together with dial gauge holder.

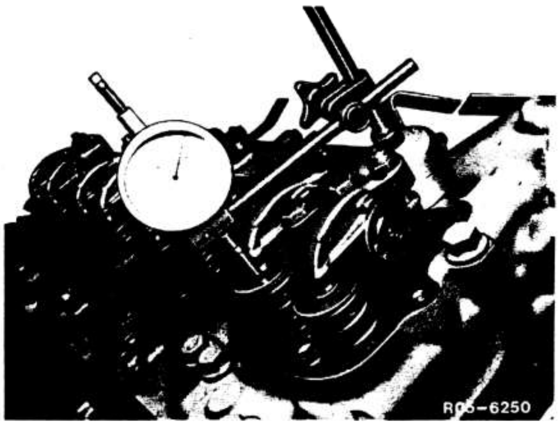
11 Set piston of cylinder No. 1 to overlap TDC.

12 Mount dial gauge holder.
Set dial gauge under preload on the valve spring plate of the exhaust valve and set scale to "0".

13 Crank engine further in normal direction of rotation and observe dial gauge until the pointer of the dial gauge stops.

14 Read off measured value TDC exhaust

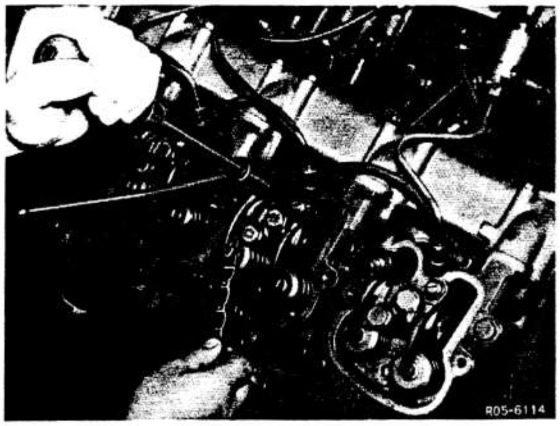
Dial gauge	001 589 53 21 00
Dial gauge holder	363 589 02 21 00



15 Remove dial gauge holder and dial gauge.

16 Set valve clearance of cylinder No. 1.

17 Mount valve covers and detach cranking device.

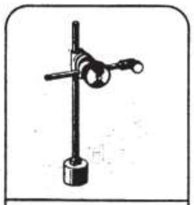


05 – 6210 Checking Axial Clearance of Camshaft

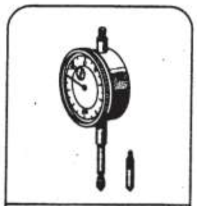
Data

Permissible axial clearance of camshaft	0.2–0.9

Special tools



363 589 02 21 00



001 589 53 21 00

Preparatory work

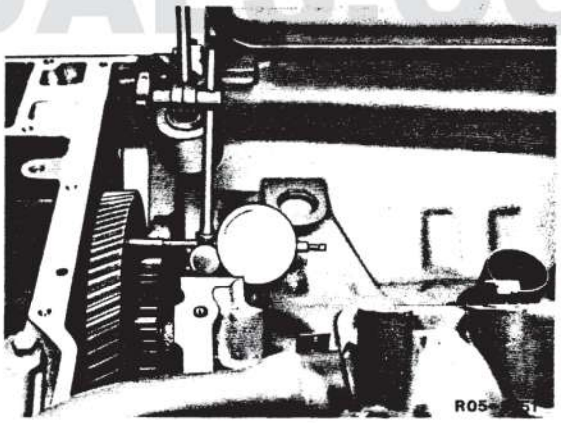
Remove cover from timing case and crankcase.

Remove injection pump.

Checking axial play

1 Press camshaft at the camshaft gear against the timing case.

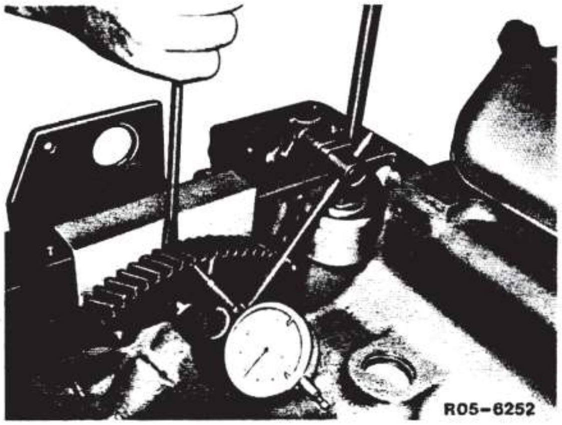
2 Mount dial gauge holder together with dial gauge on the crankcase. Set dial gauge under preload on the camshaft gear and set scale to "0".



R05-[illegible]51

3 Press camshaft at the camshaft gear against the dial gauge and read off axial clearance of the camshaft on the dial gauge.

Dial gauge holder	363 589 02 21 00
Dial gauge	001 589 53 21 00



R05–6252

05 – 6300 Removal and Installation of Camshaft

Preparatory work

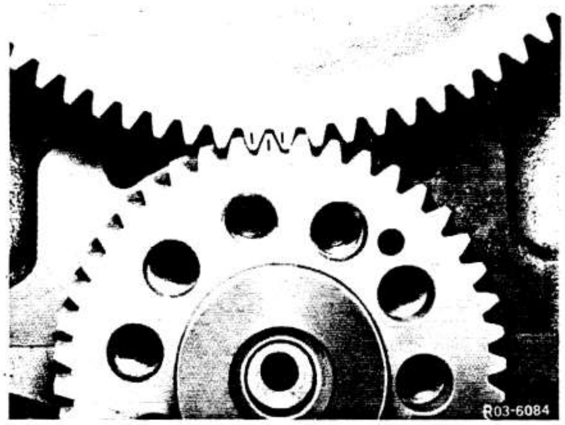
Remove engine.
Remove rocker arm brackets.
Remove push rods.
Overturn engine (cylinder heads facing downwards).
Remove oil pan.
Remove timing case.

Removal

1 Remove tachometer drive (if fitted) from front of crankcase.

2 Crank engine in normal direction of rotation until the camshaft marking agrees with the crankshaft marking.

3 Carefully remove the camshaft ensuring the bearings are not damaged.

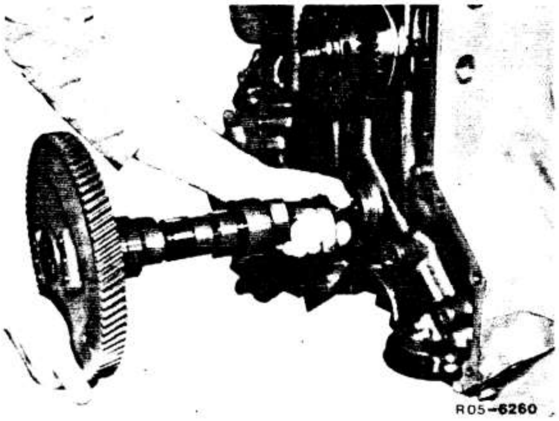


Installation

1 Carefully fit the camshaft in the crankcase, ensuring the bearings are not damaged.

Note: Take particular care to ensure that the tooth of the crankshaft gear marked with 1 is positioned between the teeth of the camshaft gear also marked with 1–1.

2 Fit tachometer drive.



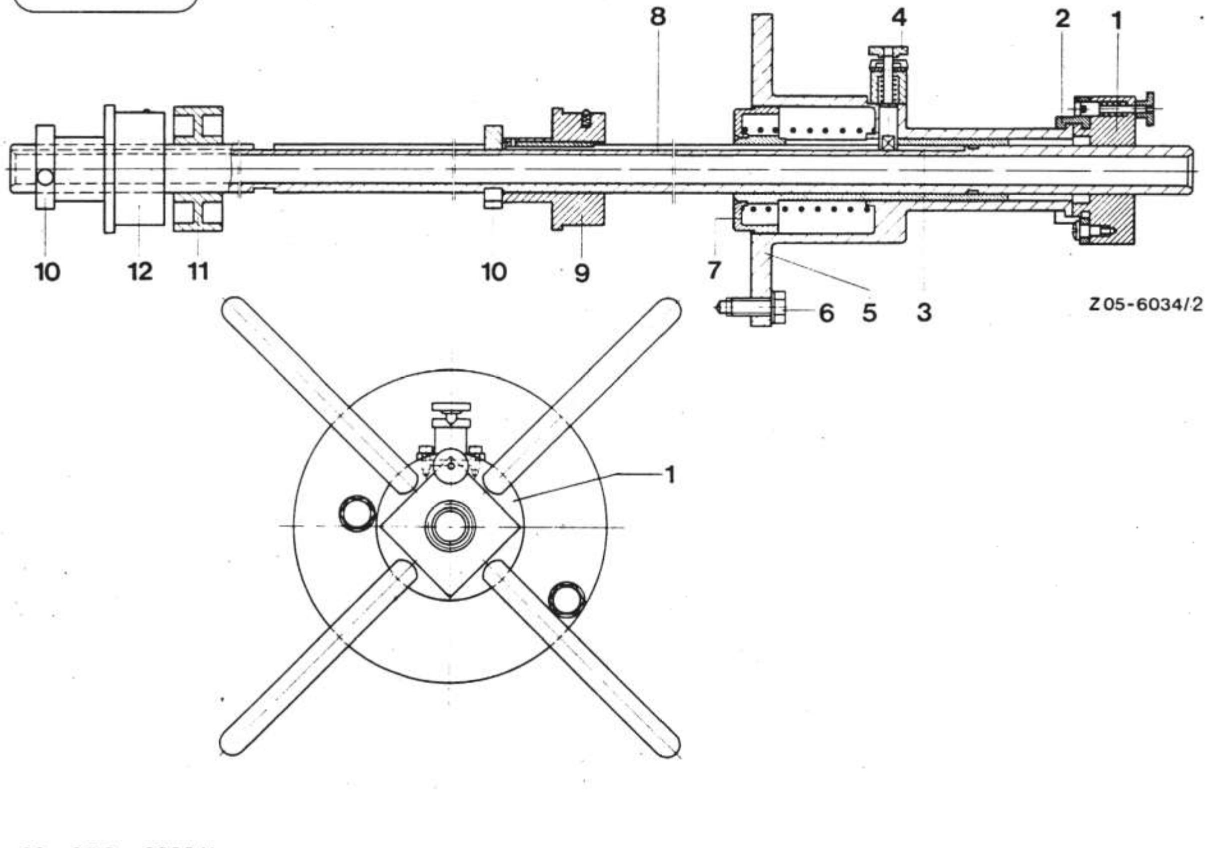
05 – 6320 Renewing Camshaft Bearings

Data

Camshaft diameter			69.940 69.910
Inside diameter of bearing		Flanged bearing (thrust bearing)	70.090 70.070
		Remaining bearings	70.030 70.000
Camshaft clearance	Radial	Flanged bearing	0.13–0.18
		Remaining bearings	0.06–0.12
	Axial		0.2–0.9

Special tools

403 589 02 33 00



Extractor/Installer

1 Cross-type handle
2 Half shell
3 Bearing housing
4 Lock pin
5 Bearing flange
6 Bolt M 10 x 25
7 Centering tube
8 Spindle tube
9 Bearing holder
10 Locking piece
11 Locating ring
12 Flanged bearing

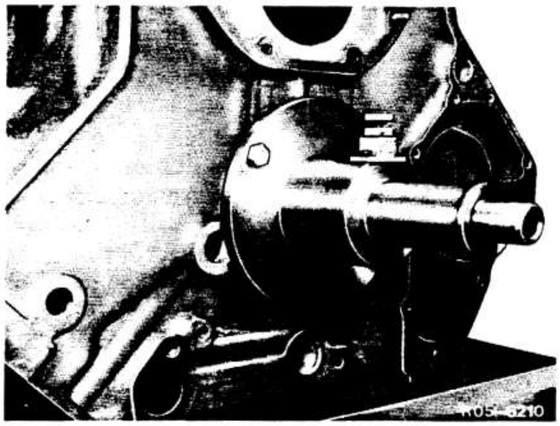
Preparatory work

Remove camshaft.

Remove crankshaft.

Removal

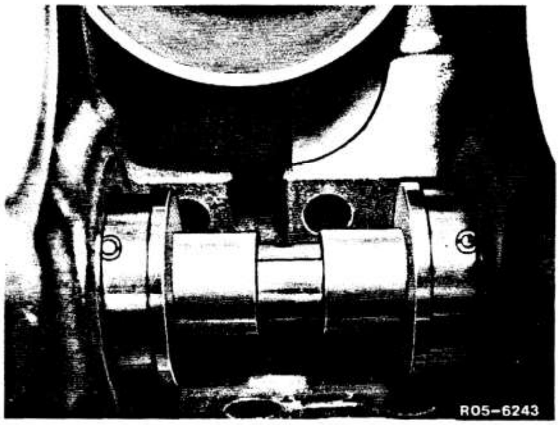
1 With 2 bolts M 10 x 25, bolt the bearing flange and centering tube to the crankcase.



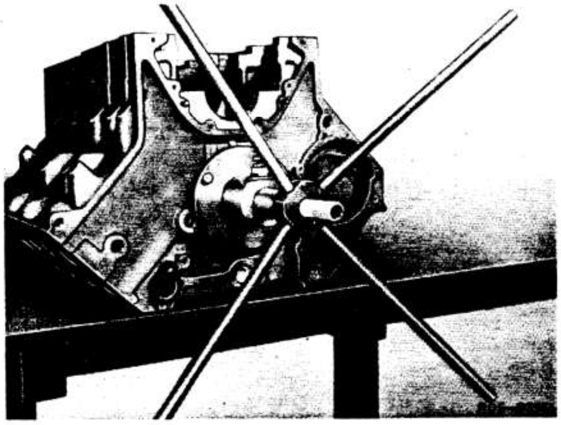
2 Insert the spindle tube in the crankcase and position 2 bearing holders behind the relevant bearing point.

Note: Insert bearing holders for the flanged bearing in opposed arrangement.

3 Turn spindle tube until the lock pin in the bearing housing engages in the groove of the spindle tube.

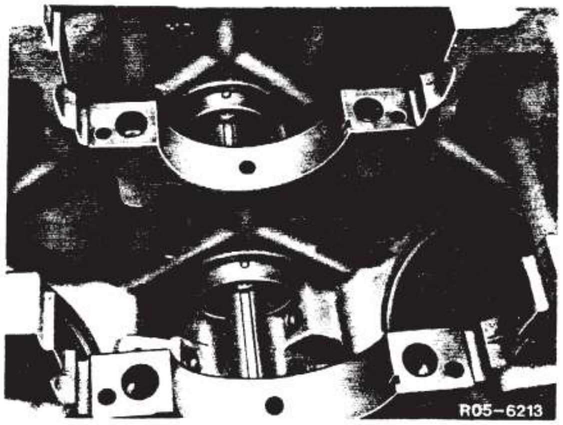


4 Fit cross handle on the thread of the spindle tube.



5 Insert bearing holder in bearing, position locking pieces in the grooves behind the bearing holders and remove bearing by turning the cross handle.

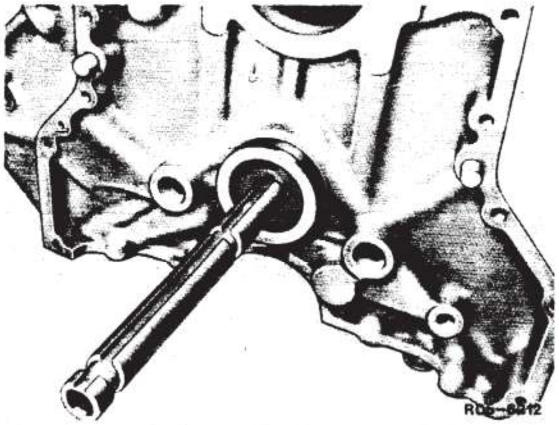
Note: In order to remove the bearing holders, the spindle tube can be withdrawn from the crankcase with the cross-handle still attached.


R05-6213

6 The flanged bearing is pressed out towards the rear. For this purpose, the cross-handle must be connected with the bearing flange with the aid of the half shell.

7 Unscrew the cross-handle and remove spindle tube together with the bearing holders and bearings, unscrew bearing flange.

8 Thoroughly clean bearing points in the crankcase.

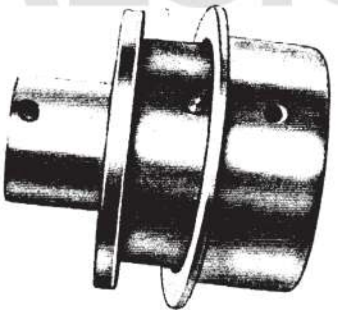

R05-6212

Installation

1 Using 2 bolts M 10 x 25, bolt the bearing flange and centering tube to the crankcase.

2 Place camshaft bearing bushes on the holders and lock in position.

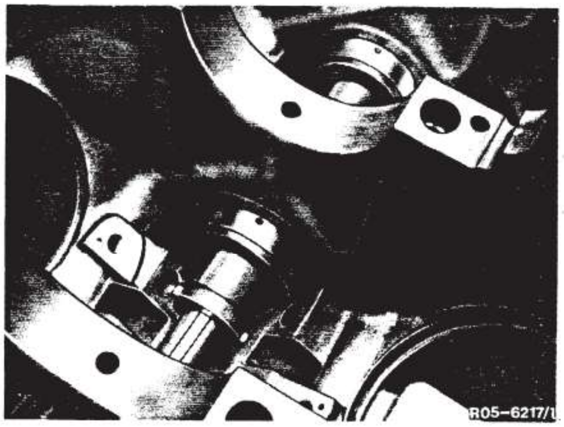
3 Insert spindle tube in the crankcase and fit bearing holders with bearing at the relevant bearing point. Turn spindle tube until the lock pin in the bearing housing engages in the groove of the spindle tube.


R05-6214/1

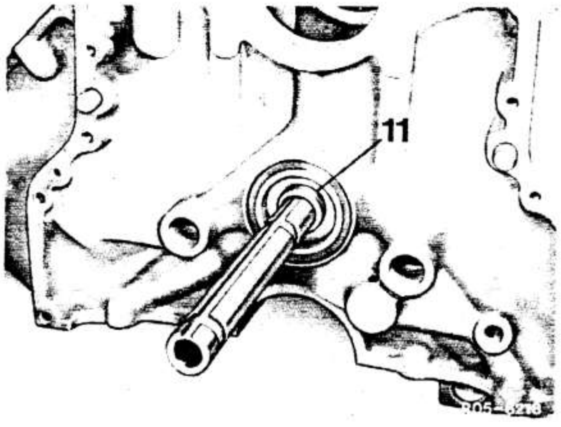
Note: By locking the bearing holder to the spindle tube the oil hole of the bearing is also fixed with respect to the crankcase.

4 Insert locking piece in the spindle tube, mount cross-handle and pull in bearing until the oil hole of the bearing is aligned with the oil hole in the crankcase.

Note: Before installation, coat outside of bearing shells with engine oil.

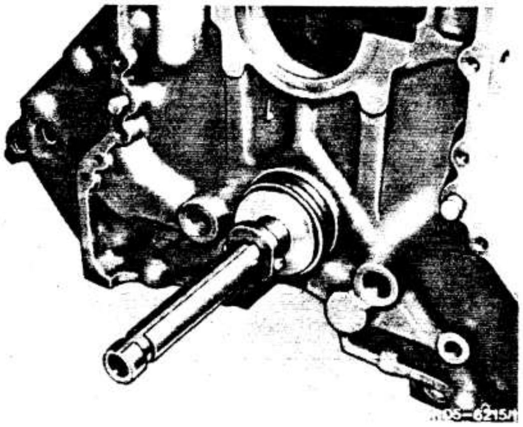

R05-6217/1

5 When fitting the inner bearing shells, the locating ring (11) must be inserted in the bearing point of the flanged bearing.



Note: Due to the considerable manual effort required, it is advisable to fit a maximum of only 2 bearings per fitting operation. In order to remove the bearing holders, the spindle tube can be withdrawn from the crankcase with the cross-handle still attached.

6 When locking the flanged bearing in position on the bearing holder particular care must be taken to ensure that the lower hole of the bearing shell is located to the right with respect to the center line.



7 Remove bearing installer and measure bearing.

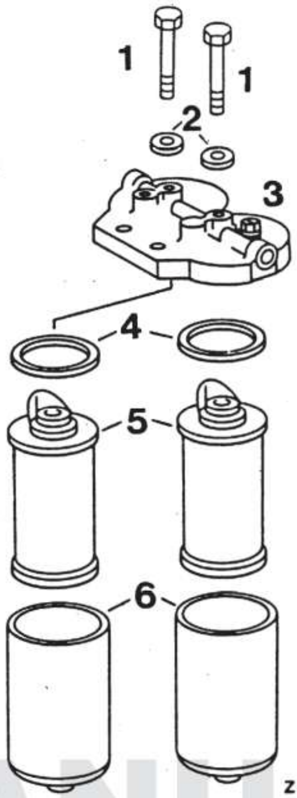
8 Check clear passage of oil ducts.

07 – 0002 Injection Pump Installation Survey

Engine Engine output rpm	Injection pump Bosch designation	MB Part No.	Governor Bosch designation	Remarks
OM 441 150 kW 204 HP 1800 rpm	PE 6 P 110 A320 LS 3835 0401 846 823	013 074 87 02	RQ 300/900 PA 187–14	Standard
	PE 6 P110 A320 LS 3835 0401 846 824	013 074 88 02	RQV 300–900 PA 524–10	Optional extra
OM 441 150 kW 204 PS 1900 rpm	PE 6 P110 A320 LS 3835 0401 846 829	015 074 06 02	RQ 300/950 PA 827–1 K	Standard
	PE 6 P110 A320 LS 3835 0401 846 830	015 074 07 02	RQV 300–950 PA 829 K	Optional extra
OM 441 160 kW 218 PS 2100 rpm	PE 6 P110 A320 LS 3835–1 0401 846 870	016 074 57 02	RQ 300/1050 PA 827–4 K	Standard
	PE 6 P110 A320 LS 3835–1 0401 846 880	016 074 88 02	RQ 300/1050 PA 187–19	Standard
	PE 6 P110 A320 LS 3835–1 0401 846 871	016 074 58 02	RQV 300–1050 PA 829–4 K	Optional extra
	PE 6 P110 A320 LS 3835–1 0401 846 881	016 074 89 02	RQV 300–1050 PA 884	Optional extra
OM 441 LA 243 kW 330 HP 2100 rpm	PE 6 P120 A320 LS 7808 0402 646 838	014 074 02 02	RQ 300/1050 PA 762–4	Standard
	PE 6 P120 A320 LS 7808 0402 646 843	014 074 03 02	RQV 300–1050 PA 797–2	Optional extra
OM 442 191 kW 260 HP 1900 rpm	PE 8 P110 A320 LS 3842 0401 848 783	013 074 32 02	RQ 300/950 PA 187–15	Standard
	PE 8 P110 A320 LS 3842 0401 848 784	013 074 33 02	RQV 300–950 PA 524–11	Optional extra
OM 442 191 kW 260 HP 2100/min	PE 8 P110 A320 LS 3842 0401 848 790	015 074 76 02	RQ 300/1050 PA 187–17	Standard
	PE 8 P110 A320 LS 3842 0401 848 793	015 074 77 02	RQV 300–1050 PA 524–12	Optional extra

Engine Engine output rpm	Injection pump Bosch designation	MB Part No.	Governor Bosch designation	Remarks
OM 442 206 kW 280 HP 1900 rpm	PE 8 P110 A32 LS 3842 0401 848 781	015 074 08 02	RQ 300/950 PA 827 K	Standard
	PE 8 P110 A320 LS 3842 0401 848 782	015 074 09 02	RQV 300–950 PA 829–1 K	Optional extra
OM 442 213 kW 290 HP 2100 rpm	PE 8 P110 A320 LS 3842 0401 848 786	013 074 30 02	RQ 300/1050 PA 827–3 K	Standard
	PE 8 P110 A320 LS 3842 0401 848 794	016 074 81 02	RQ 300/1050 PA 187–18	Standard
	PE 8 P110 A320 LS 3842 0401 848 791	013 074 31 02	RQV 300–1050 PA 829–3 K	Optional extra
	PE 8 P110 A320 LS 3842 0401 848 795	016 074 82 02	RQV 300/1050 PA 884–1	Optional extra
OM 442 A 260 kW 364 HP 2100 rpm	PE 8 P120 A320 LS 7801 0402 648 817	011 074 36 02	RQ 300/1050 PA 762 RQ 300/1050 PA 762–5	Standard Standard
	PE 8 P120 A320 LS 7801 0402 648 825	012 074 80 02	RQV 300–1050 PA 797–1 RQV 300–1050 PA 797–3	Optional extra Optional extra
OM 442 LA 320 kW 435 HP 2100 rpm	PE 8 P120 A320 LS 7801 0402 648 812	011 074 37 02	RQ 300/1050 PA 717	Standard
	PE 8 P120 A320 A3 LS 7803 0402 698 801	013 074 61 02		EDR
	PE 8 P120 A320 LS 7801 0402 648 824	012 074 81 02	RQV 300–1050 PA 797	Standard
OM 443 265 kW 360 HP 2100 rpm	PE 10 P110 A320 LS 3844 0401 849 737	013 074 34 02	RQ 300/1050 PA 827–5 K	Standard
	PE 10 P110 A320 LS 3844 0401 849 741	016 074 90 02	RQ 300/1050 PA 187–20	Standard
OM 443 LA 401 kW 545 HP 2100 rpm	PE 10 P120 A320 LS 7809–1 0402 649 801	016 074 31 02	RQ 300/1050 PA 717–1	Standard
	PE 10 P120 A320 LS 7809–1 0402 649 803	016 074 32 02	RQV 300–1050 PA 797–4	Optional extra

07 – 5520 Renewing and Bleeding Fuel Filter

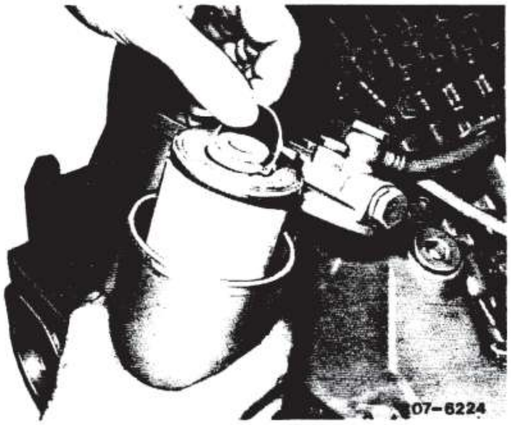


1	Bolt	15 Nm
2	Sealing ring	renew
3	Cover	
4	Sealing ring	renew
5	Filter element	renew
6	Filter bowl	

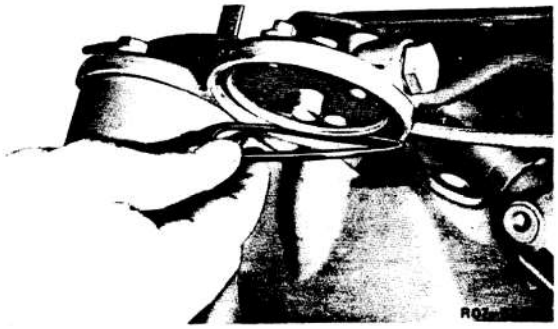
Renewing fuel filter

1 Unscrew filter bowl and remove.

2 Lift out filter element and wash out filter bowl.

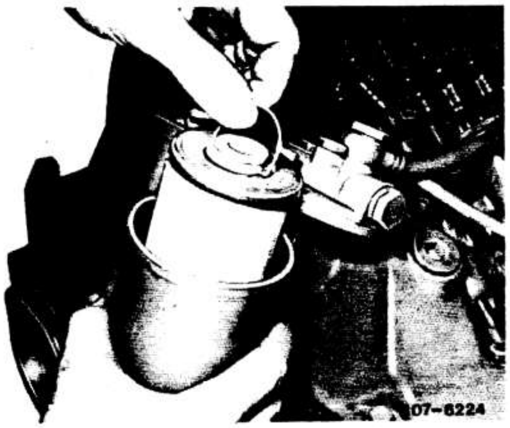


3 Remove sealing ring from the filter housing and fit new sealing ring in the filter housing.



4 Position filter bowl with new filter element on the filter housing and tighten to 15 Nm.

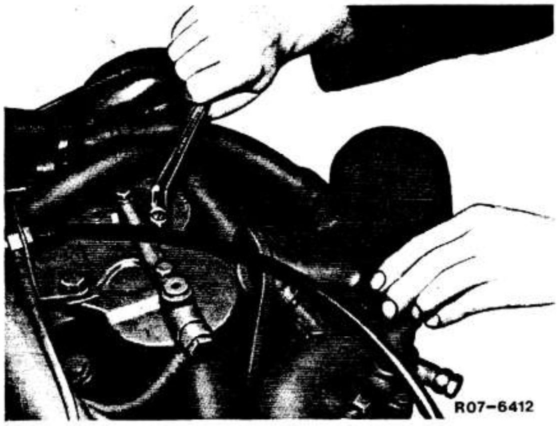
5 Bleed fuel system.



Bleeding

1 Unscrew bleeder screw on fuel filter by 1 to 2 turns. Operate hand primer until bubble-free fuel emerges at the bleeder screw. Tighten bleeder screw.

Note: For naturally aspirated engines, the hand primer is mounted on the injection pump.



07 – 6712 Checking Injection Nozzle

Data

Engine	Injection nozzle	Vibration group number	Injection pressure Setting	 Minimum permissible value of used nozzles
441.905/907/912/913/914 442.905/906/907/908/909/914/915/916 917/920/921 443.905	DLLA 136 S 1034[1] OLL 136S 10082[1]	2	175 + 10 bar	165 bar
441.906	DLLA 136S 1043			
441.951/961 442.950/951/952/953/958/959/962/964/965/966/980/983 443.980	DLLA 134 S 999	2	200 + 8 bar	175 bar

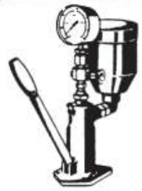
Industrial engine

441.901–400 442.901–500 444.901.500	DLLA 134 S 999	2	200 + 8 bar	175 bar
444.901.501	DLLA 134 S 1035	2	200 + 8 bar	175 bar

[1] Option

[2] The pressure difference of the nozzles within one engine must not be more than 10 bar.

Special tools



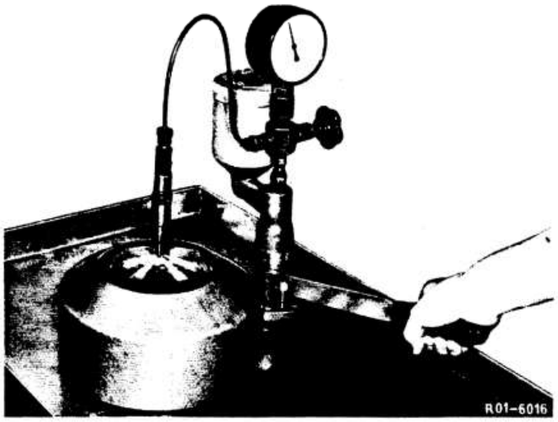
000 589 14 27 00

Checking injection nozzle

1 Carefully remove coking deposits on the nozzle.

2 Screw nozzle together with nozzle holder onto nozzle testing unit.

3 Check injection nozzle for leaks.
Only clean test oil or filtered diesel oil must be used for testing. When testing a nozzle, on no account place hand in the jet of a spraying nozzle. The jet can penetrate deeply into the flesh and destroy tissue. The fuel which penetrates into the bloodstream can cause blood poisoning.

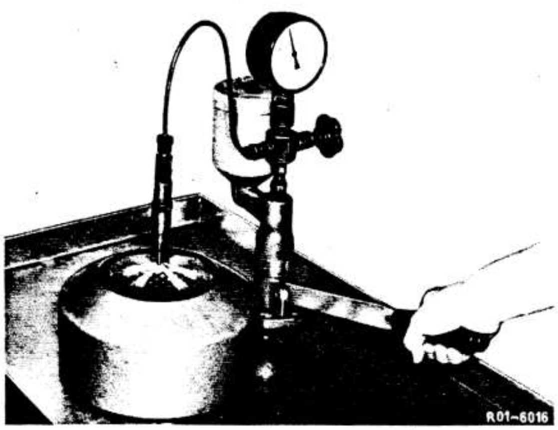


Nozzle testing unit 000 589 14 27 00

Slowly press down pump lever until the pointer on the pressure gauge is 20 bar below the set opening pressure. The nozzle is not leaking when no drop forms at the nozzle mouth within 10 seconds. If the injection nozzle is leaking, disassemble and clean.
Renew nozzle if a leak cannot be eliminated by thorough cleaning of the seat surfaces at the nozzle body and at the nozzle needle.

4 Check opening pressure of the injection nozzle.

Slowly press down hand pump lever of the nozzle testing unit with the pressure gauge connected (1 stroke per second) and read off the opening pressure at the opening point or when the nozzle begins to spray.



Note: With the pressure gauge set, increase the pressure only slowly and above all reduce the pressure only slowly otherwise the pressure gauge can be damaged.

Nozzle testing unit 000 589 14 27 00

If the opening pressure is too high or too low, the injection nozzle must be disassembled, cleaned and set correctly.

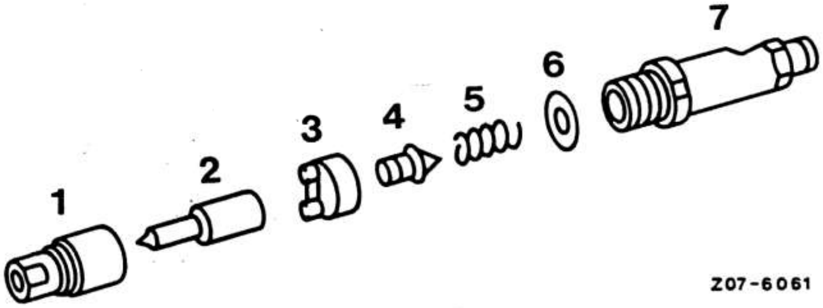
If the pressure is too high, replace the washers by thinner ones if the pressure is too low fit thicker washers.

Vibration characteristic/jet pattern
(Vibration group No. 2)

a) **Vibration characteristic:** Regular vibration at fast and slow lever speed. Short areas without vibration can occur.

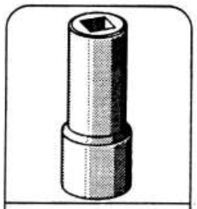
b) **Jet pattern:** At low test speed, spread coarsely atomized straight jet in area without vibration. As the lever speed increases the jets become full and finely atomized.

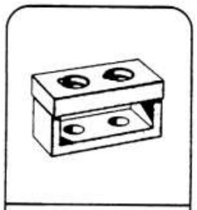
07 – 6750 Disassembly, Cleaning and Assembly of Nozzle Holder and Injection Nozzle



1	Pressure nut	75 Nm, special tool 403 589 00 13 00
2	Nozzle	Special tool 000 589 00 68 00
3	Intermediate disc with locating pin	
4	Thrust pin	
5	Compression spring	
6	Washer	
7	Nozzle holder	Special tool 403 589 00 31 00

Special tools


403 589 00 13 00

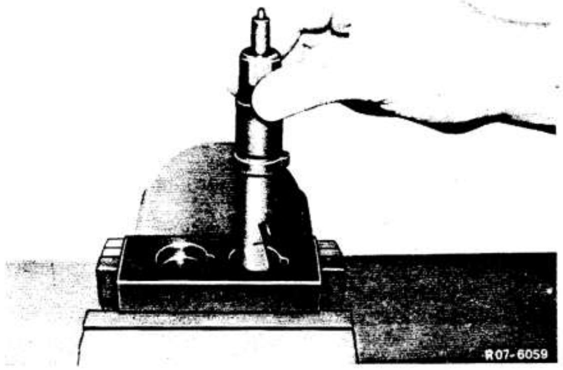

403 589 00 31 00

000 589 00 68 00

Disassembly, cleaning and assembly

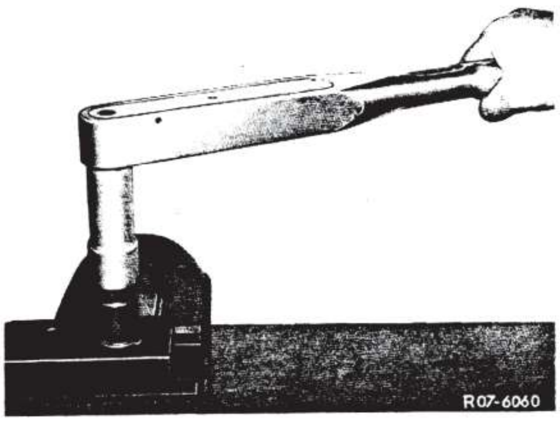
1 Insert nozzle holder in special tool.

Holder 403 589 00 31 00



2 Using special tool, unscrew pressure nut from nozzle holder and disassemble nozzle.

Special wrench 403 589 00 13 00


R07-6060

3 Using a small piece of wood soaked in diesel fuel, clean the disassembled nozzle on the outside and inside particularly the needle seat and the ring groove. Clean the injection holes of the nozzle body with a cleaning needle from special tool 000 589 00 68 00.

Nozzle cleaning unit 000 589 00 68 00

R 07-6006

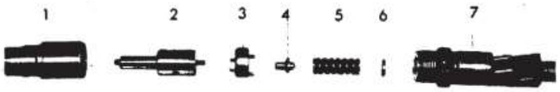
4 Immerse nozzle needle and nozzle body in clean diesel fuel and check the sliding properties with the drop test.

Drop test: When the nozzle needle, withdrawn by 1/3 from the nozzle body is released, it must slide down to the seat under its own weight. If this is not the case, the nozzle and the nozzle body must be renewed.

5 Assembly nozzle. Ensure the locating pins on the intermediate disc are fitted correctly.

Note: A corresponding washer (6) must be installed if the opening pressure was found to be too high or too low during nozzle testing.

If the pressure is too high install a thinner washer, if the pressure is too low fit a thicker washer.

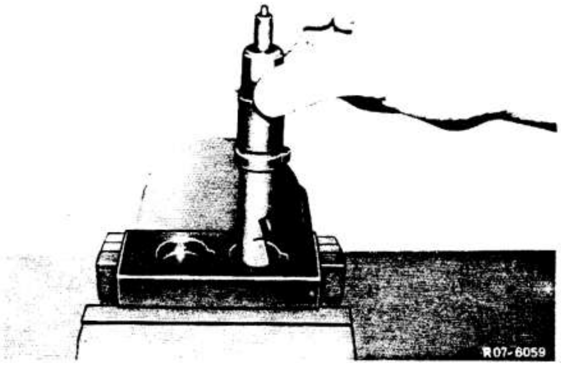


1 Pressure nut
2 Nozzle
3 Intermediate disc with locating pin
4 Thrust pin
5 Compression spring
6 Washer
7 Nozzle holder

R 01-6017

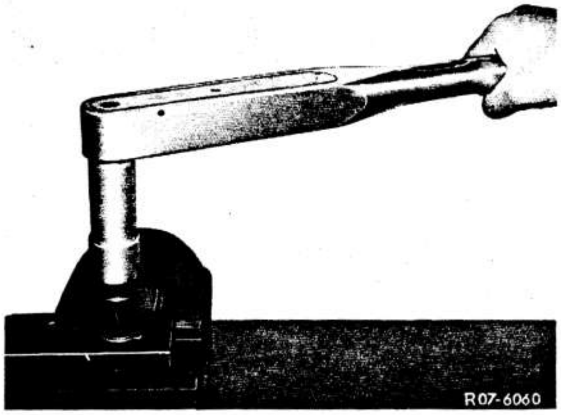
6 Insert nozzle holder in special tool.

Holder 403 589 00 31 00

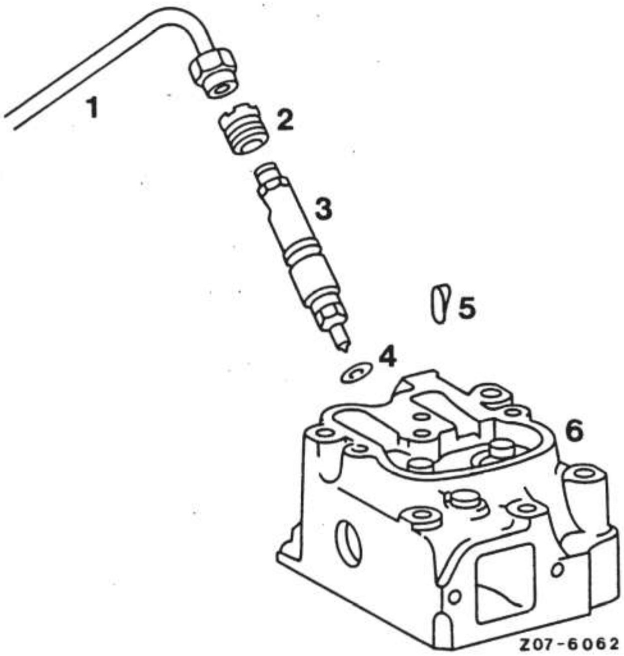


7 Tighten pressure nut with special wrench to 75 Nm.

Special wrench 403 589 00 13 00

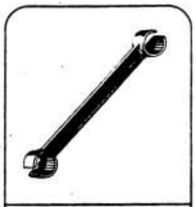


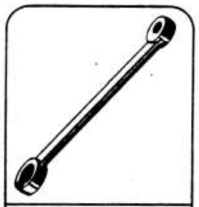
07 – 6812 Removal and Installation of Injection Nozzle with Nozzle Holder

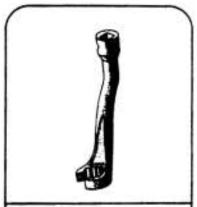


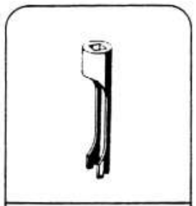
1 Injection line	25 Nm, special tool 000 589 07 03 00, 000 589 50 03 00, 000 589 68 03 00
2 Pressure screw	70 Nm, special tool 403 589 03 07 00, 403 589 04 07 00, 403 589 05 07 00
3 Nozzle holder	Special tool 355 589 01 63 00
4 Sealing ring	renew
5 Plug	
6 Cylinder head	

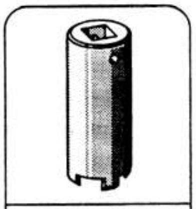
Special tools

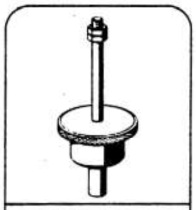

000 589 07 03 00

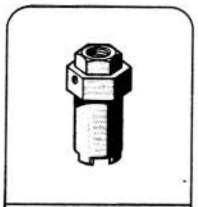

000 589 50 03 00


000 589 68 03 00


403 589 03 07 00


403 589 04 07 00

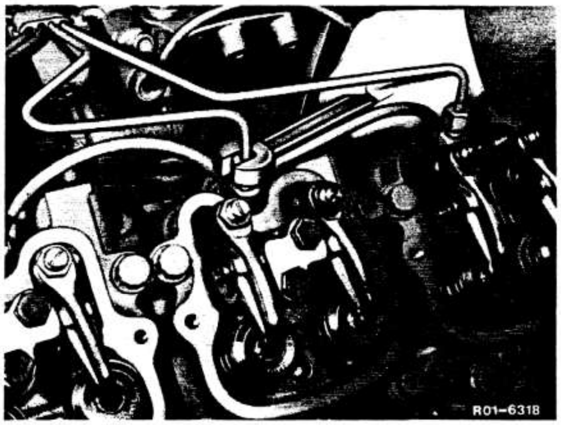

355 589 01 63 00


403 589 05 07 00

Removal

1 Using special wrench, unscrew union nut of the injection line at the nozzle holder.

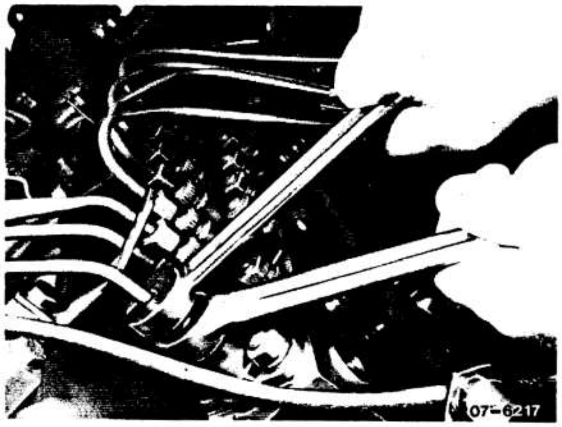
Special wrench 000 589 07 03 00



2 Using special wrench, loosen union nut at the injection pump, while holding the pipe connection with the box wrench. Place injection line on one side.

Note: Bending the injection line must be avoided on all accounts.

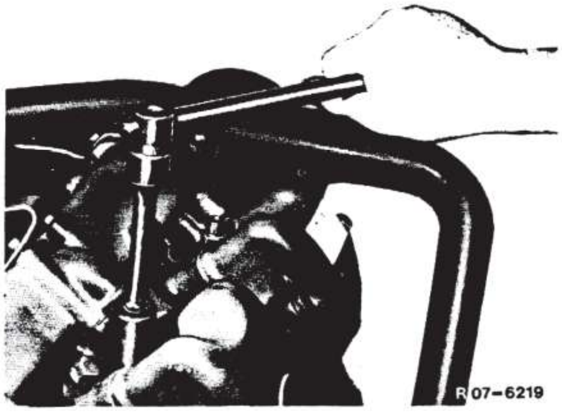
Special wrench 000 589 07 03 00
Box wrench 000 589 50 03 00



3 Detach fuel hoses for leakage fuel or rubber cap from the hose coupling of the injection nozzle. Remove rubber cap from the groove in the cylinder head.

4 Unscrew pressure screw of the nozzle holder with pin wrench.

Pin wrench	403 589 04 07 00
Pin wrench in extreme case	403 589 05 07 00

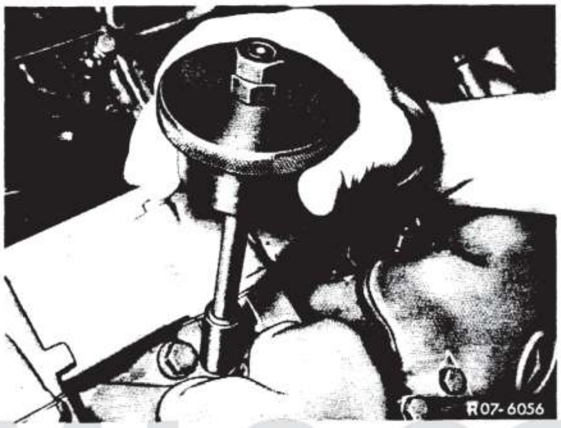


5 Using striking tool, knock nozzle holder out of the cylinder head.

6 Remove sealing ring from the cylinder head.

Note: Check the injection nozzles with the nozzle testing unit prior to reinstallation. Repair or replace nozzles which are not in perfect operating condition.

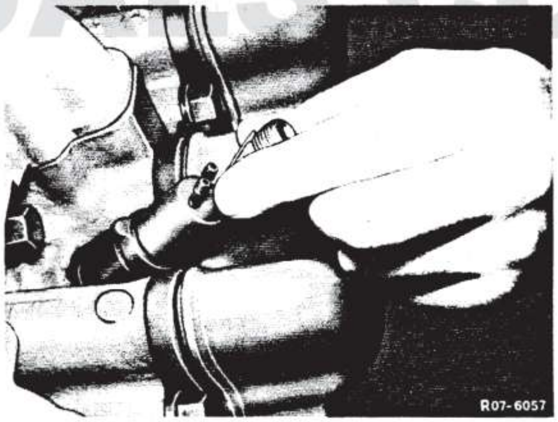
Striking tool 355 589 01 63 00



Installation

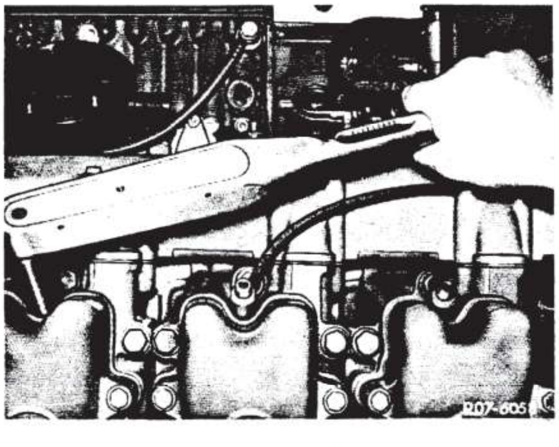
1 Insert new sealing ring for injection nozzles in the cylinder head.

2 Insert nozzle holder with nozzle in cylinder head, while ensuring the locating lug on the nozzle holder and groove in the cylinder head are fitted correctly. Do not knock nozzle.

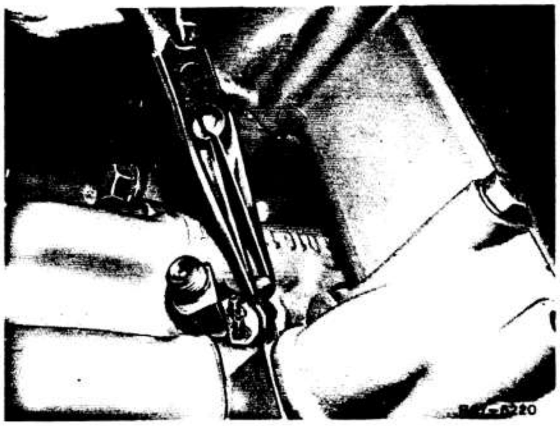


3 Screw in pressure screw with pin wrench and tighten to 70 Nm.

Pin wrench 403 589 04 07 00



4 Insert rubber plug in the groove in the cylinder head.



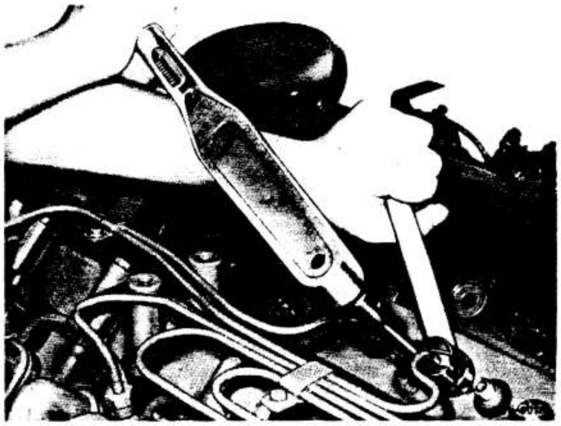
5 Attach leakage fuel hoses on the hose couplings of the injection nozzles.

6 Place injection line on nozzle holder and tighten to 25 Nm with special wrench.

Special wrench 000 589 68 03 00

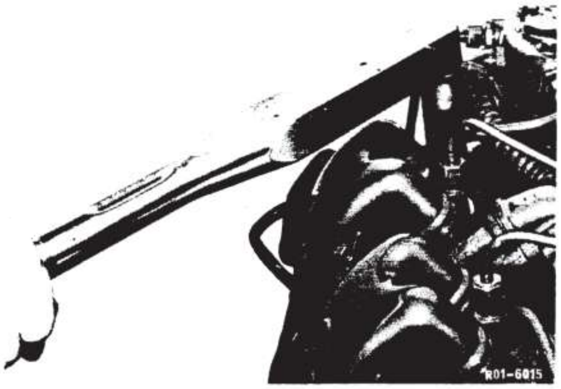
7 Tighten union nut at the injection pump with special wrench to 25 Nm, while holding the pipe connection at the injection pump with the box wrench.

Special wrench	000 589 68 03 00
Box wrench	000 589 50 03 00



Note: Use special wrench to retighten the pressure screws for the nozzle holders.

Special wrench 403 589 03 07 00



07 – 8234 Checking Start of Delivery

Data

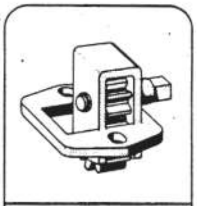
Engine	Start of delivery
441.906/907 442.905/908/909	12° before TDC
441.905/912/913/914 442.906/907/914/915/916/917/920/921 443.905	14° before TDC
442.950/961/952/953/958/959/962/963/964/965/966/980/982/983 443.980	
441.951/961	10° before TDC

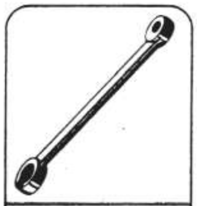
Industrial engine

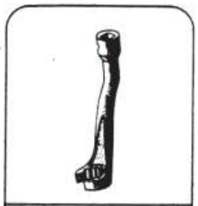
442.901–400 442.901–500 444.901–400 444.901–500	14° before TDC
444.901–501	13° before TDC

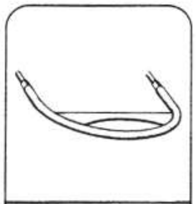
Tightening torques	Nm
Injection lines	25
Holder of fuel filter to timing case cover	80
Timing case cover	25
Drive gear	35

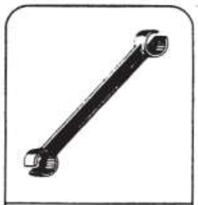
Special tools

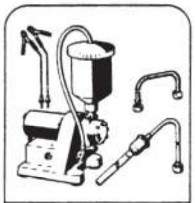

407 589 00 63 00

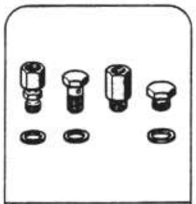

000 589 50 03 00

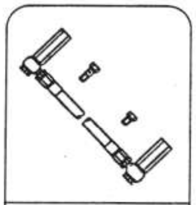

000 589 68 03 00


403 589 05 63 00


000 589 07 03 00


422 589 00 71 00

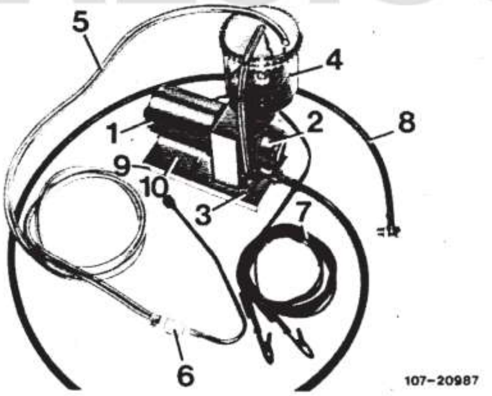

403 589 00 91 00


442 589 01 90 00

Checking start of delivery

High pressure pump

1 Electric motor
(DC 12 V/15 A)
2 Gear pump
3 Pressure relief valve
4 Fuel reservoir
5 Return line
6 Sight glass with test line
7 Connection cable
8 Connection line (supply)
9 Base plate
10 Relay box with switch

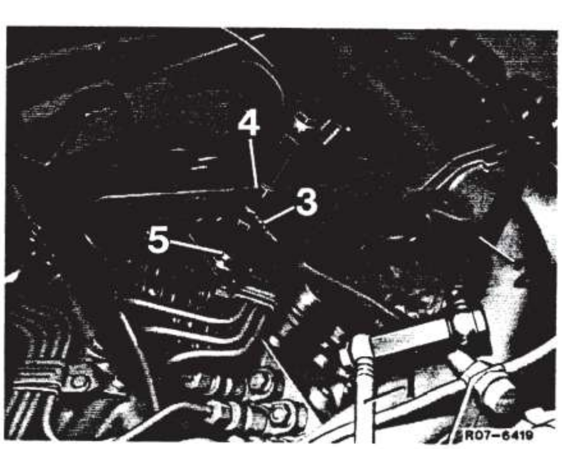


Note: The points 1 to 3 must be carried out as follows for vehicles with electronic diesel control:

Remove supply line at the injection pump (1) and connect to the test line (2).

Connect supply line from the high pressure pump to the injection pump.

Test line 442 589 01 90 00



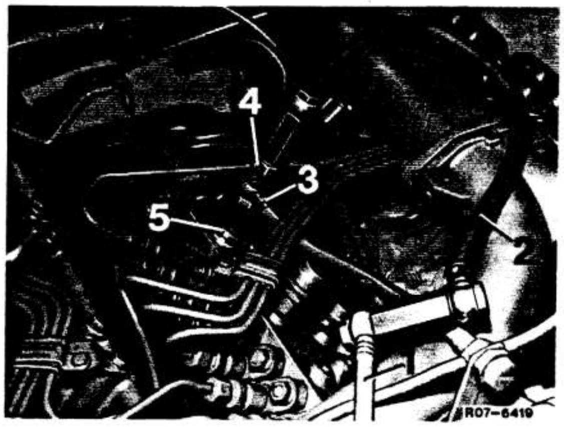
Remove return line (3) together with overflow valve (4) at the injection pump and connect to test line (1).

Close off pump return with dummy plug (5).

Switch on ignition.

Operate mode pickup in full load position. Operation of the electrical fuel pumps ensures the control rod of the injection pump is moved to full load control.

Test line 442 589 01 90 00



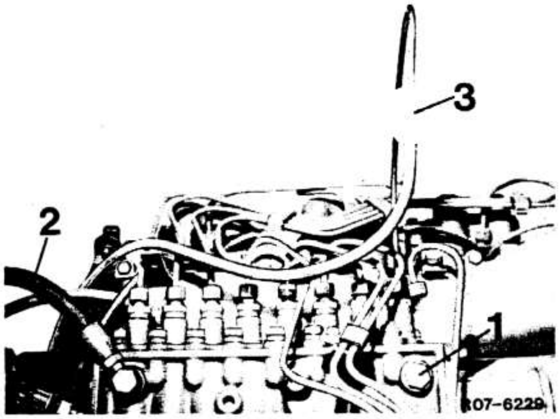
1 Remove fuel supply line at the injection pump and connect supply line from the high pressure pump (2).

2 Detach fuel return line and overflow valve at the pump and close off hole with dummy plug (1).

3 Press injection pump lever to full load and switch on high pressure pump.

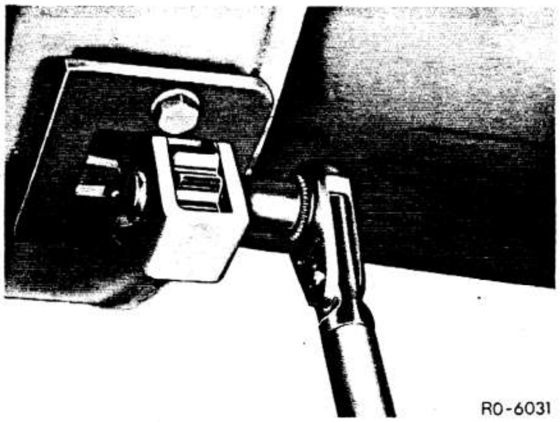
Engine cranking device 407 589 00 63 00

4 Remove injection line to engine cylinder No. 1. Connect test line with sight glass to the connection of the injection pump for the **engine cylinder No. 1** (3).



5 Attach special tool and set engine to approx. ½ turn before TDC.

6 Connect high pressure pump to a **12 V** battery.

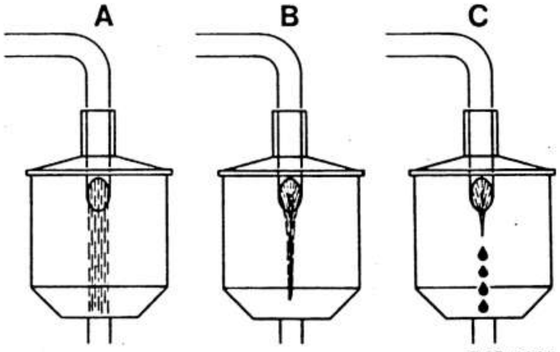


7 Slowly crank engine in normal direction of rotation and observe the flow of fuel in the sight glass until the fuel jet is constricted to drop form. The exact start of delivery setting is achieved at this transition point.

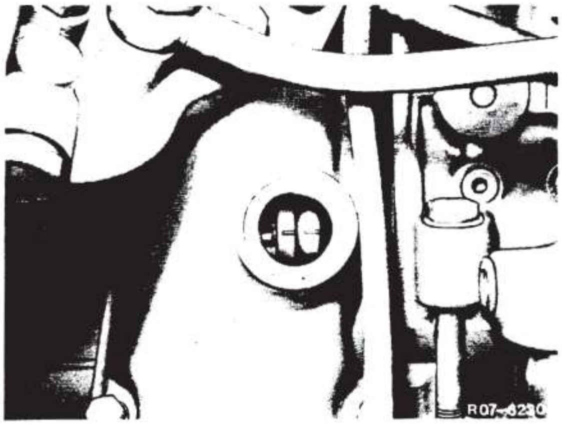
A = Fuel jet "full"

B = Fuel jet constricted "just **before** start of delivery"

C = String of drips, start of delivery

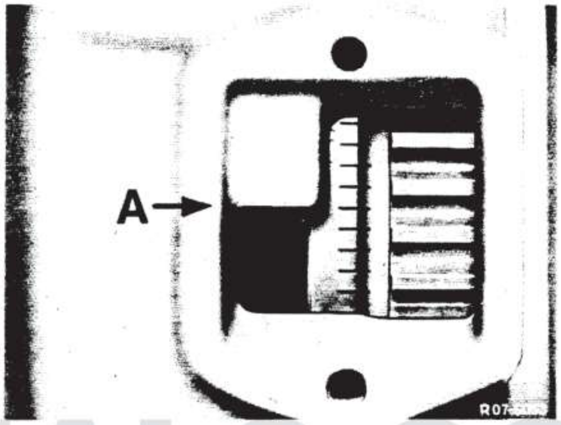


8 Remove dummy plug from the timing case cover. Check start of delivery marking between the drive gear and pump flange through the inspection hole in the timing case cover and between the flywheel end edge of the inspection hole.

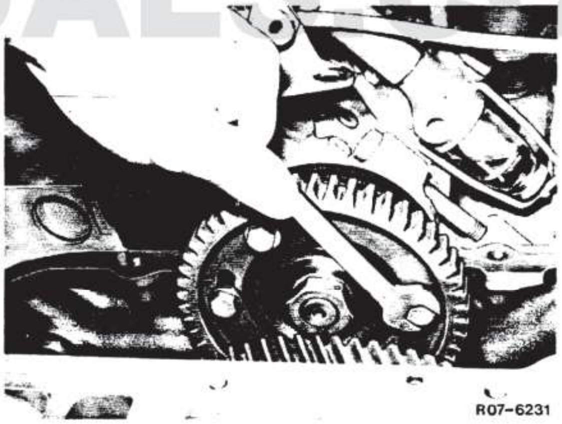


9 If it is necessary to correct the start of delivery setting, set the engine – in normal direction of rotation – exactly to the start of delivery between the flywheel and edge of the inspection hole.

A = Start of delivery marking

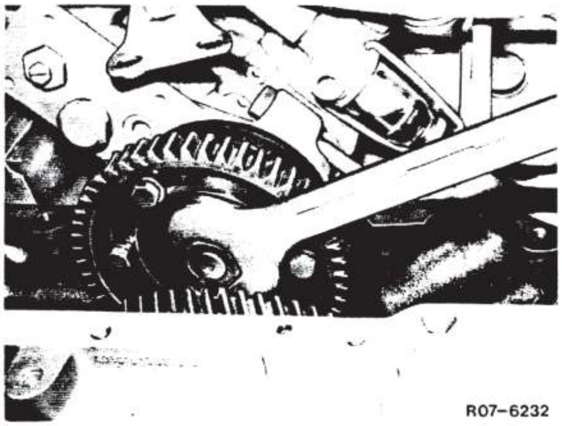


10 Remove timing case cover and fuel filter and release securing bolts between injection pump and drive gear.


R07-6231

11 Press lever of injection pump to full load and switch on high pressure pump.

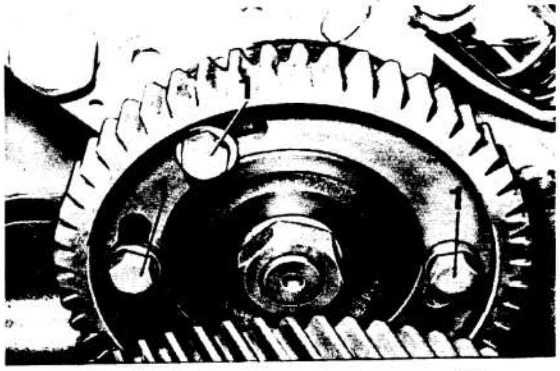
12 Turn the camshaft of the injection pump at the securing nut of the drive flange until the fuel jet in the sight glass changes from the constriction to a string of drops.


R07-6232

13 Tighten the securing bolts of the injection pump drive gear crosswise to 35 Nm.

14 As a check, repeat start of delivery test Points 4–8.

1 Securing bolts



R07–6233

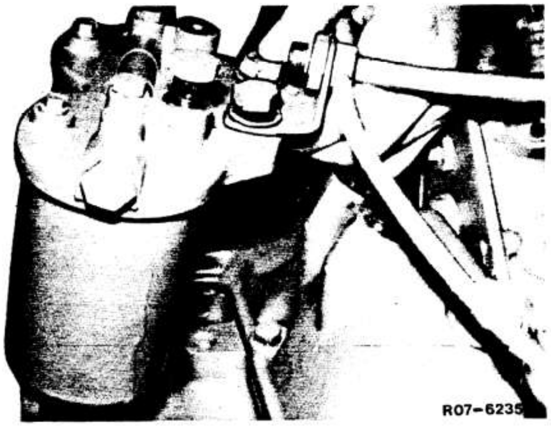
15 Install timing case cover and fuel filter.

16 Detach high pressure pump.

17 Install injection line.

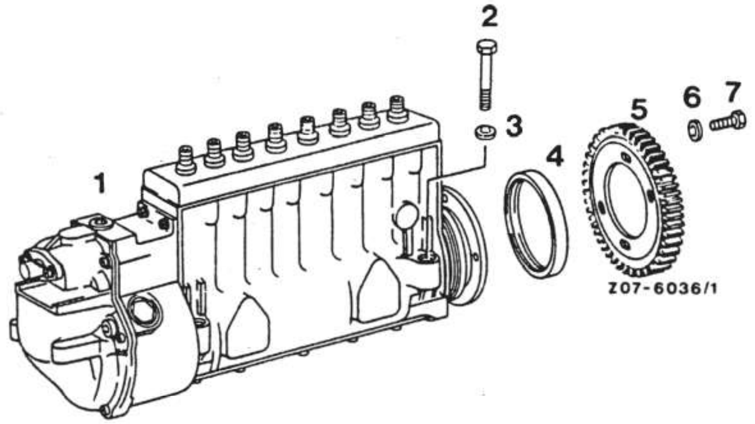
18 Install fuel supply line.

19 Install fuel return line with overflow valve.



R07–6235

07 – 8410 Removal and Installation of Injection Pump



1	Injection pump	
2	Bolt	50 Nm, refer to tightening diagram
3	Washer	
4	Sealing ring	renew
5	Drive gear	
6	Washer	
7	Bolt	35 Nm

Data

Engine	Start of delivery
441.906/907 442.905/908/909	12° before TDC
441.905/912/913/914 442.906/907/914/915/916/917/920/921 443.905	14° before TDC
442.950/951/952/953/958/959/962/963/964/965/966 980/982/983/ 443.980	
441.951/961	10° before TDC

Industrial engine

442.901-400 442.901-500 444.901-400 444.901-500	14° before TDC
444.901-501	13° before TDC

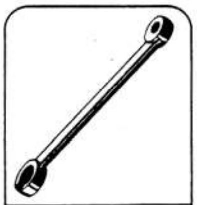
Injection pump operating sequence

441 441 LA	6, 3, 5, 2, 4, 1
442 442 A 442 LA	8, 7, 2, 6, 3, 5, 4, 1
443 443 LA	10, 9, 4, 1, 8, 7, 6, 3, 5, 2
444 A[1] 444 LA[1]	12, 1, 5, 9, 8, 3, 4, 11, 10, 2, 6, 7

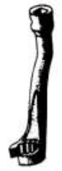
[1] Industrial engine

Gear backlash	$\frac{0.338}{0.102}$

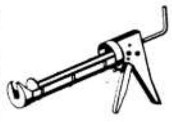
Special tools



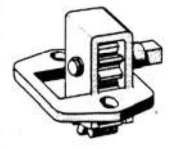
000 589 50 03 00



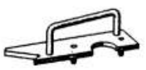
000 589 68 03 00



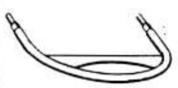
000 589 01 25 00



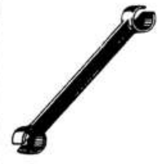
407 589 00 63 00



403 589 04 63 00

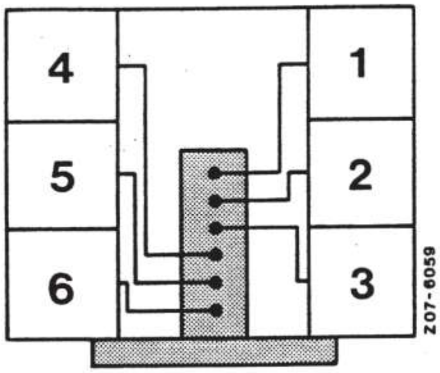


403 589 05 63 00

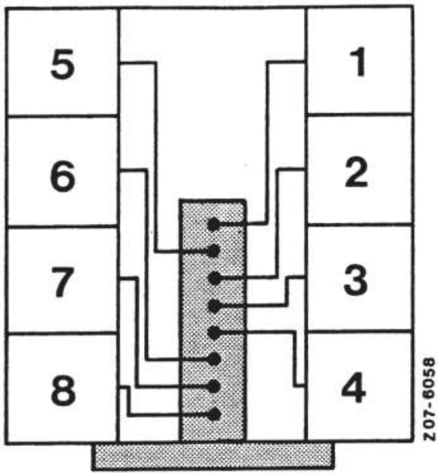


000 589 07 03 00

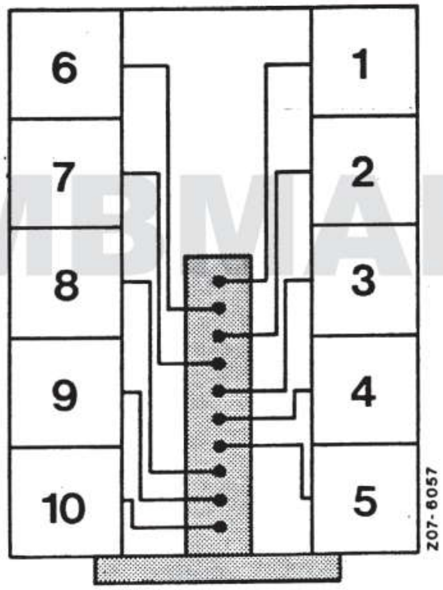
Arrangement of injection lines


4
1
5
2
6
3
Z07-6059

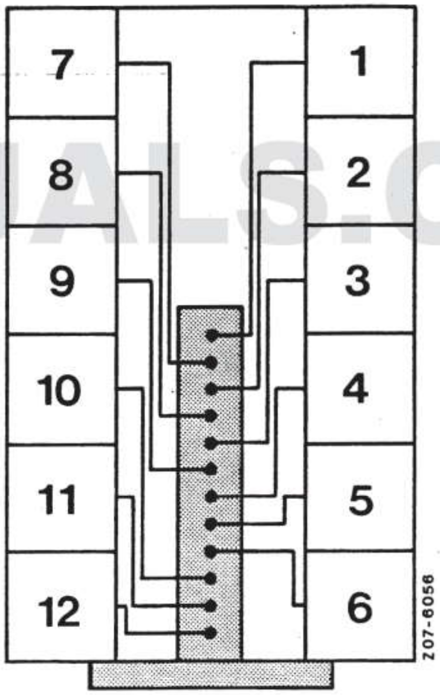
OM 441
OM 441 LA


5
1
6
2
7
3
8
4
Z07-6058

OM 442
OM 442 A
OM 442 LA


6
1
7
2
8
3
9
4
10
5
Z07-6057

OM 443
OM 443 LA

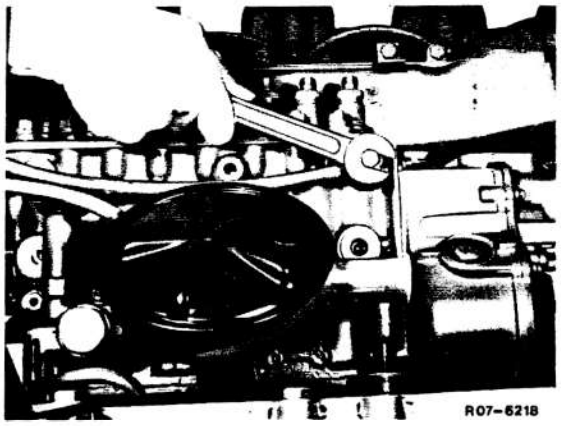

7
1
8
2
9
3
10
4
11
5
12
6
Z07-6056

Industrial engine
OM 444 A
OM 444 LA

Removal

1 Unscrew fuel lines at the injection pump.

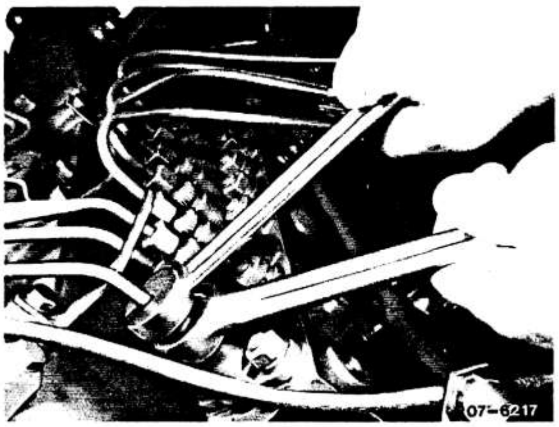
Note: Detach charge air pipe from the charge air cooler on turbocharged engines.



2 Unscrew union nut of the injection lines with a special wrench at the nozzle holder and at the injection pump while firmly holding the pipe connection of the injection pump with a box wrench.

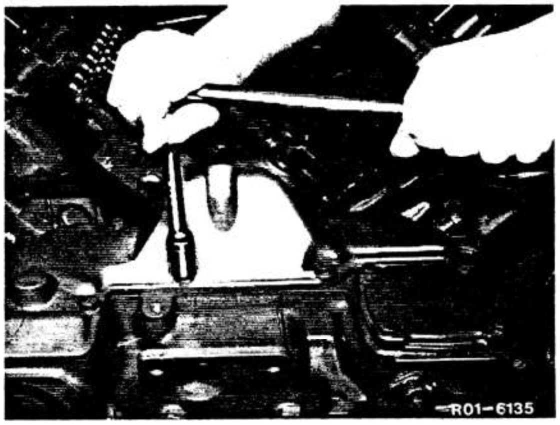
Note: Bending the injection lines must be avoided on all accounts.
In the case of VN control, detach linkage from servo motor at the ball socket of the injection pump.
In the case of turbocharged engines (A and LA), remove the charge air line to the LDA governor.

Special wrench	000 589 07 03 00
Box wrench	000 589 50 03 00



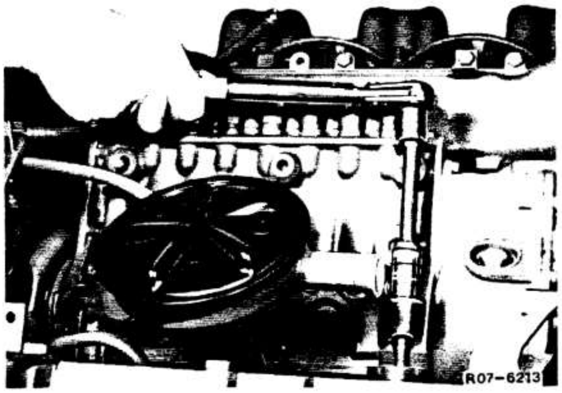
3 Detach operating cylinder at the control lever of the injection pump from the ball socket.

4 Unscrew timing case cover and remove.

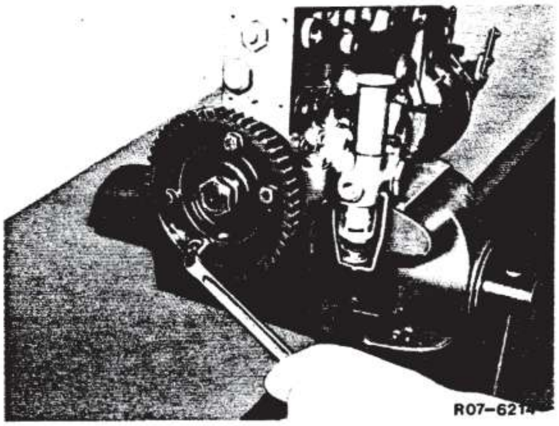


5 Unscrew bolts holding the injection pump.

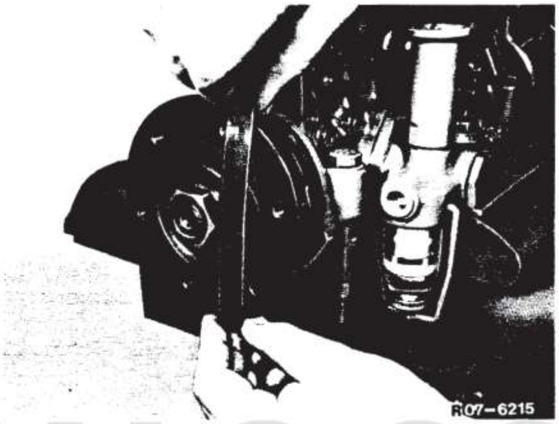
6 Remove injection pump.



7 Unscrew drive gear of injection pump.



8 Remove sealing ring from the injection pump.

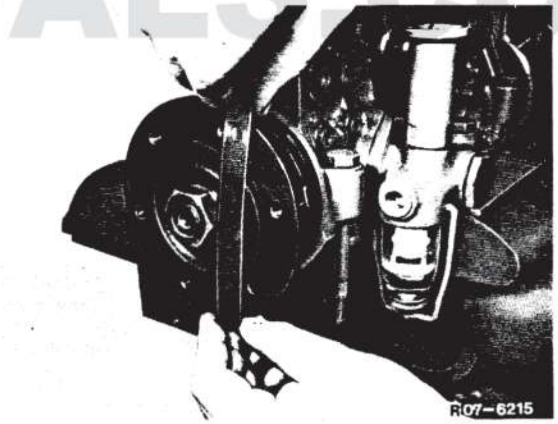


Installation

1 Attach cranking device to timing case.

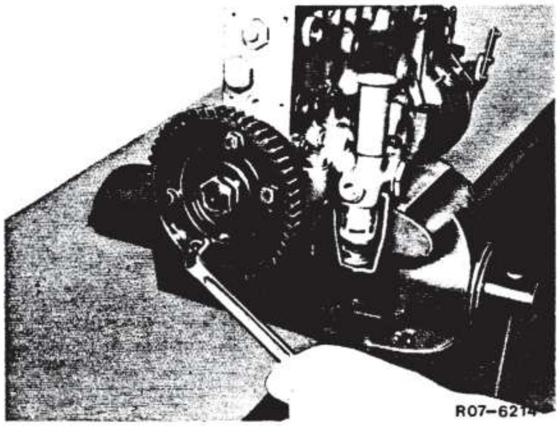
Cranking device 407 589 00 63 00

2 Place sealing ring over the drive flange of the injection pump.

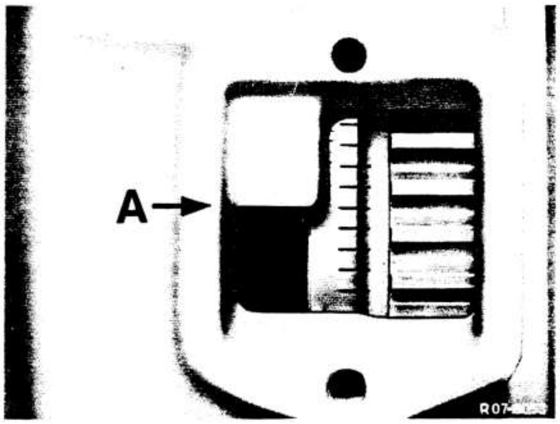


3 Bolt the drive gear to the injection pump.

Note: Only tighten bolts hand tight.



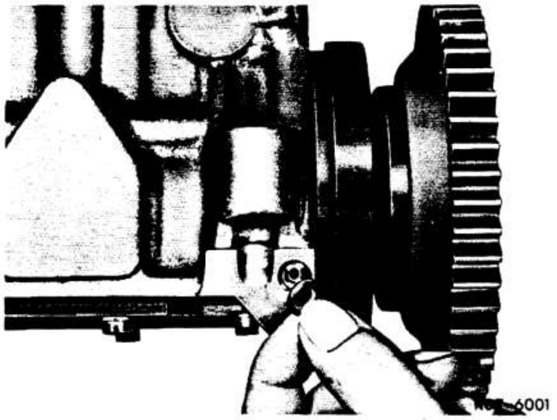
4 With the aid of the cranking device, set engine to start of delivery in the compression stroke of cylinder No. 1. The engine must not be turned back (the valves of cylinder No. 1 are closed and both valves of cylinder No. 7 in the 443 engine or cylinder No. 6 in the 442 engine or cylinder No. 5 in the 441 engine are slightly open).



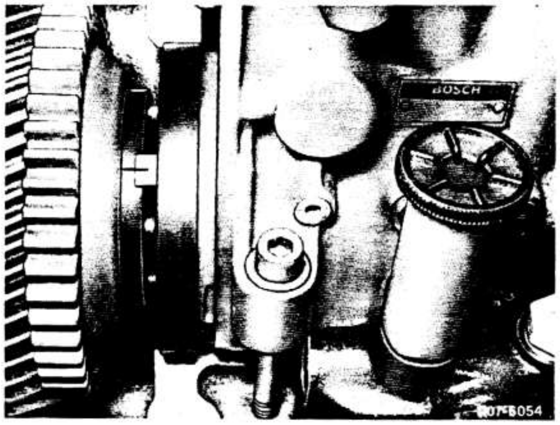
5 Turn camshaft of the injection pump such that the marking on the drive flange agrees with the marking on the injection pump.

6 Fit new O-ring in the oil duct of the injection pump.

Note: Position the drive gear of the injection pump in the center of the slots.

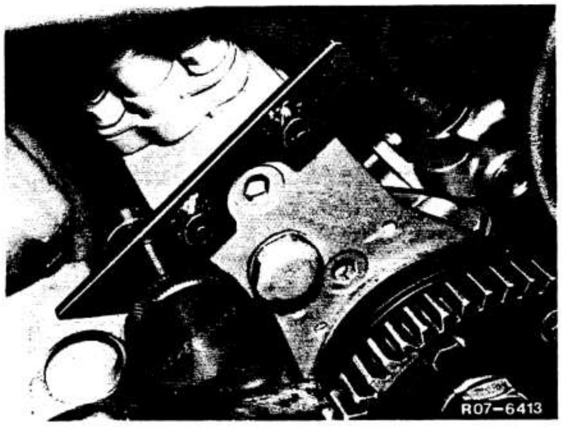


7 Fit injection pump in the mounting point on the crankcase while ensuring the markings on the injection pump agree. The drive gear must engage smoothly in the gearing of the injection timing device.



Note: The correct installation position of the injection pump is achieved with the aid of the setting gauge.

Previous setting gauge	403 589 04 63 00
New setting gauge	422 589 00 63 00



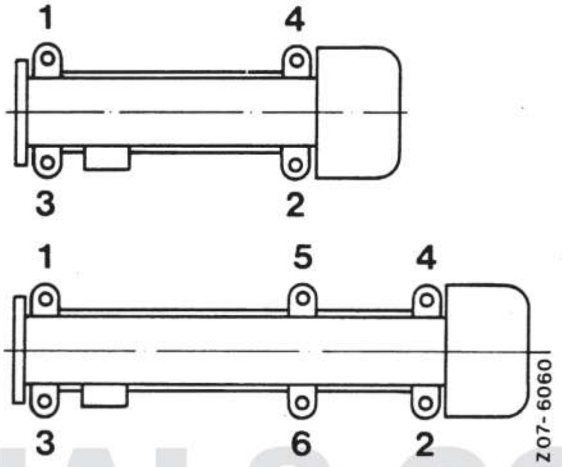
8 Screw in securing nuts of the injection pump with spherical washers and tighten cross wise to 50 Nm.

Injection pump tightening diagram

a) Align the injection pump with assembly gauge.

b) Tighten bolts in 2 stages

1st. stage	10 Nm
2nd. stage	50 Nm



9 Tighten securing bolts of the drive gear to 35 Nm.

10 Once again check start of delivery.

11 Connect fuel lines.

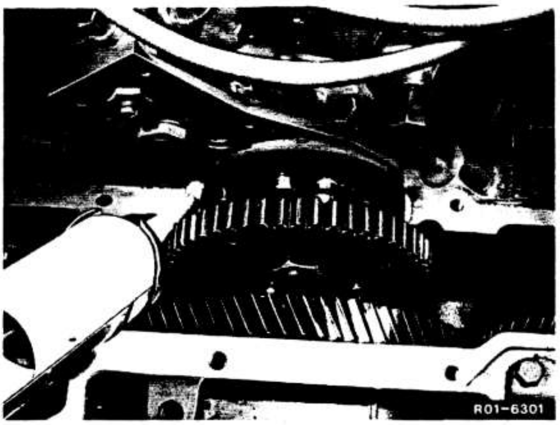
12 Attach injection lines ensuring they are not stressed and tighten to 25 Nm. Firmly hold the pipe connection of the injection pump with a box wrench.

Special wrench	000 589 68 03 00
Box wrench	000 589 50 03 00

13 Attach operating cylinder to control lever.

14 Remove grease at both corners between the mating surface of the crankcase and gasket, injection pump flange and seal with silicon sealing compound.

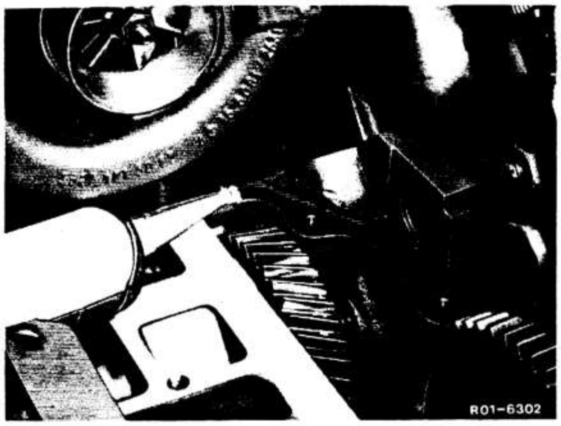
Hand gun 000 589 01 25 00



R01-6301

15 Seal mating surface on the left and right between crankcase and timing case with silicon sealing compound.

Hand gun 000 589 01 25 00



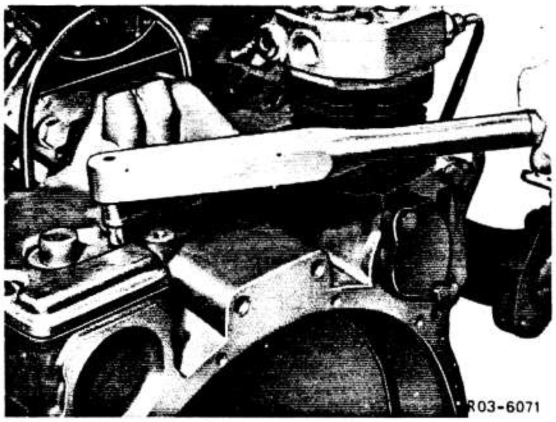
R01-6302

16 Fit timing case cover, attach assembly fixture, screw in securing bolts and tighten to 25 Nm.

Assembly fixture 403 589 04 63 00

17 Remove cranking device from timing case.

Note: Attach bracket with servo motor for v + n control.
Attach charge air line to LDA governor for turbocharged engines (A and LA).
Attach charge air pipe from charge air cooler on turbocharged engine (LA).
The governor housing must be filled with 1.5 l engine oil before putting into operation.



R03-6071

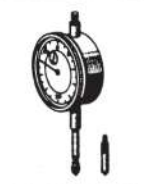
09 – 6010 Checking Turbocharger, Determining Findings

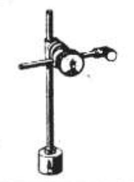
Turbocharger removed

Data

Max. permissible axial clearance	0.16 mm
Max. permissible radial clearance	0.45 mm
Max. speed of turbocharger rpm	approx. 105.000

Special tools


001 589 53 21 00


363 589 02 21 00

Measuring axial clearance

1 Clamp turbocharger in vice (turbine side facing upwards). Use soft jaw guards.

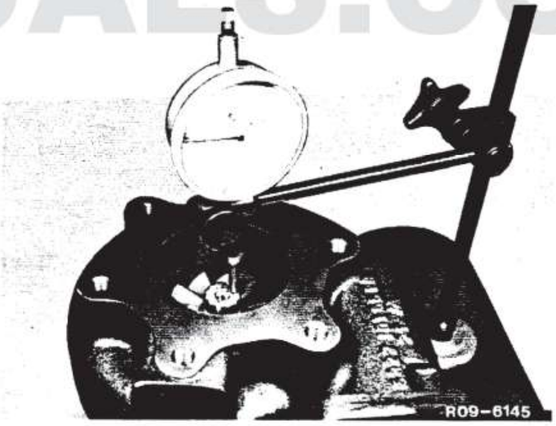
2 Mount dial gauge in dial gauge holder.

3 Set plunger of dial gauge on the shaft end of the turbine wheel.

4 Press down rotor shaft and set dial gauge to "0".

5 Press rotor shaft against the dial gauge and read off clearance. Max. permissible clearance 0.16 mm.

Dial gauge	001 589 53 21 00
Dial gauge holder	363 589 02 21 00



Measuring radial clearance

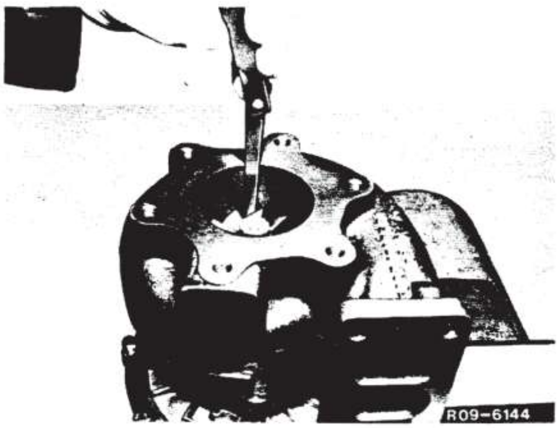
Note: The radial clearance can be determined on the turbine side only.

1 Press turbine wheel to the side, with the aid of a dial gauge, determine the gap between wheel and housing and note down.

2 Press turbine wheel in opposite direction and determine gap with feeler gauge and note down.

3 The radial clearance is derived from the difference between the two values. Maximum permissible clearance 0.45 mm.

Note: Carry out measurement at at least two different points.



Troubleshooting

Fault	Cause	Corrective measures
Exhaust clouding and drop in performance	Excessive dirt build-up in air filter	Clean or renew air filter element.
	Turbine or compressor wheel runs against housing	Repair or renew turbocharger.
	Foreign body in exhaust duct	Remove foreign body.
	Dirty compressor	Clean compressor of dirt and deposits.
	Leak between exhaust manifold and exhaust turbocharger	Reseal turbocharger to exhaust manifold.
	Valve of engine brake caught	Check engine brake valve and setting, correct if necessary.
	Charge air line deformed	Renew charge air line.
	Insufficient air	Check flange and hose connections between turbocharger and charge air pipe for leaks, repair seal if necessary.
	Exhaust pipe behind the turbocharger or silencer dirty or damaged.	Check exhaust pipe, clean, repair or renew silencer.
	Oil separator damaged or dirty.	Renew oil separator.
Oil level in turbocharger increases, oil emerges through the seal on the turbine and compressor side	The constricted line cross section as the result of coking results in an increase in the resistance to flow in the oil return line.	Clean or renew oil return line
Oil supply at turbocharger leaking	Gasket defective	Renew gasket at oil connection.
Whistling noises in the area of the turbocharger	Leaks at:	Renew defective gaskets.
	Flange connections or gaskets of the air and exhaust line or intake lines	Check flange and connections for distortion.
	Flange seals (form inaccuracy)	Check whether gaskets jut into the pipe cross sections. If so, renew gasket.

Fault	Cause	Corrective measures
Whistling noises in the area of the turbocharger	Hose or plug connections	Check hoses to ensure they are in good condition and tightly fitted.
	Rotor catching due to excessive bearing clearance	Remove lines and check housing on turbine and compressor side for scoring marks. If scoring marks are found, replace turbocharger.
Insufficient oil pressure	Oil delivery line to turbocharger damaged.	Renew oil delivery line.
Oil contamination	Oil filter dirty, wrong oil filter installed.	Renew oil filter. Install oil filter in accordance with valid spare part documentation. **Note:** Have oil contamination exactly diagnosed and rectify. Due to the high speeds, the turbocharger requires pure oil. Check whether the correct oil grade has been used (see oil label or entry in maintenance manual). Use oil grade in accordance with service product specifications, sheet 220.

Checking the turbocharger in the vehicle

Unscrew intake line at the turbocharger inlet and exhaust line at the turbine housing. Turn rotor at the compressor wheel nut or at the turbine wheel, check that it runs smoothly and uniformly. For this purpose, turn several times backwards and forwards until the rotor is free of oil carbon deposits. The rotor is stabilized as regards centrifugal forces. It is therefore mounted with relatively large clearance.

To check the axial clearance, move the rotor in longitudinal direction and check whether the turbine wheel or compressor wheel can be felt to come in contact with the housing. The axial clearance is correct if no contact is felt on both sides.

To check the radial clearance, move and turn the rotor in radial direction. The radial clearance is correct if no contact with the housing is determined.

If the turbine wheel or compressor wheel does catch against the housing, remove turbocharger, repair or replace.

Oil leaks at the turbocharger

In all types of turbocharger used by us, the oil-carrying bearing housing is sealed with piston rings with respect to the air or exhaust-carrying spiral housing. The function of this seal is based on the overpressure in the compressor housing. At increased idle speed and when coasting, however, a vacuum can occur which promotes the escape of oil and slightly wets the charge air ducts with oil.
Normal oil mist development in the air intake sysrem does not have an adverse effect on the engine. A certain amount of oil is necessary to lubricate the inlet valves. Therefore, if the charge air ducts on the clean air side show slight traces of oil, **there is no reason to remove the exhaust turbocharger.**
The air intake ducts are never completely dry since there is always slight oil precipitation in the charge air ducts as the result of oil vapours in the crankcase vent. A further cause for oil leaks can be a damaged (deformed) or dirty oil return line. The reduced line cross section can result in an increase in the resistance to flow in the oil return line. The oil level therefore increases in the turbocharger and the oil can escape via the seal on the turbine and compressor side. In this case, clean or renew the oil return line.

Installation an exchange turbocharger

Before fitting the turbocharger, the intake line and the flange elbow ahead of the compressor, the exhaust manifold and the exhaust line as well as the oil supply and return lines must be thoroughly checked for foreign bodies, dirt build-up and damage. The caps at the openings of the turbocharger should be removed only just before installation. Before connecting the oil supply line, the bearing housing must be filled with clean engine oil through the oil inlet hole. Turn rotating parts by hand to ensure oil film forms on the bearings.

Note: After a longer lay-up period of the engine and after each oil and filter change, in order to avoid premature bearing wear due to the lack of oil, before starting, crank the engine with the starter until the oil pressure gauge indicates pressure. The engine brake must be engaged or the pull stop set to "stop", otherwise the engine will start. The starter must be operated for no longer than 20 seconds otherwise it will overheat resulting in damage. If oil pressure is still not indicated, stop the start procedure and repeat after approx. 1 minute at a time.

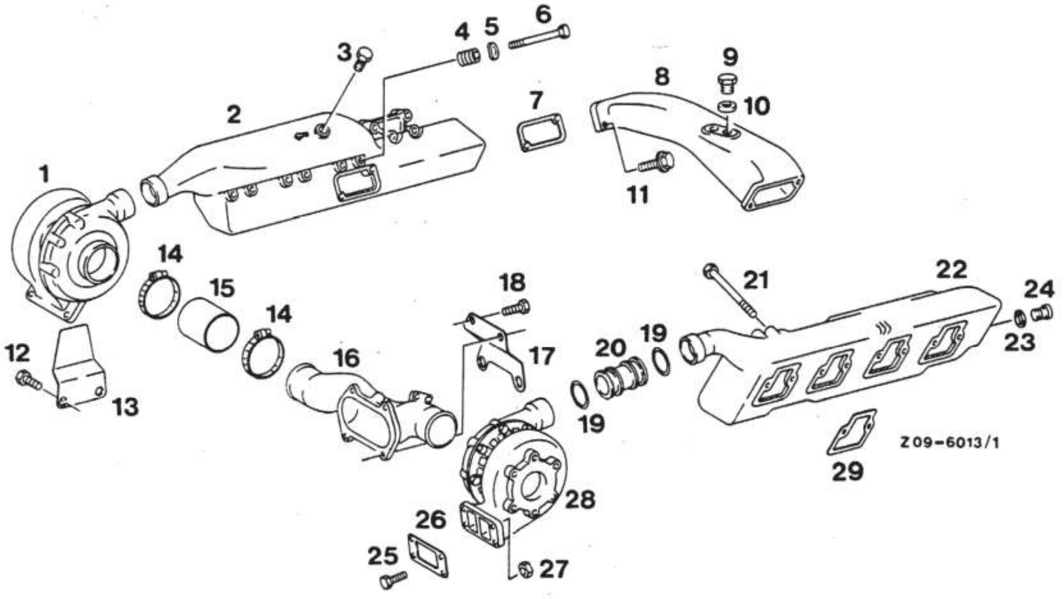
Notes on operation

Observe the following in order to avoid damage to the turbocharger by incorrect starting and stopping the engine.

After starting the engine, do not rev up immediately but rather run at idle speed until a constant oil pressure is indicated. The speed and load can then be increased.

Do not stop engine when running at high speed but rather run at idle speed for a short period in order to reduce the exhaust temperature. This procedure avoids overheating after stopping the engine.

09 – 6220 Removal and Installation of Turbocharger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Z09–6013/1

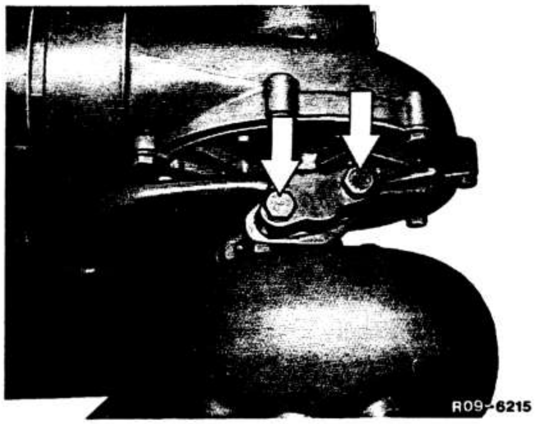
1	Turbocharger	
2	Air intake tube	
3	Screw plug	50 Nm
4	Threaded insert	
5	Spring washer	
6	Bolt	50 Nm
7	Gasket	renew
8	Air intake tube	
9	Screw plug	50 Nm
10	Sealing ring	renew
11	Bolt	50 Nm
12	Bolt	50 Nm
13	Bracket	
14	Clip	
15	Sleeve	
16	Air intake tube	
17	Bracket	
18	Bolt	50 Nm
19	Sealing ring	renew
20	Intermediate piece	
21	Bolt	50 Nm
22	Air intake tube	
23	Sealing ring	renew
24	Screw plug	50 Nm
25	Bolt	50 Nm
26	Gasket	renew
27	Nut	
28	Turbocharger	
29	Gasket	renew

Removal

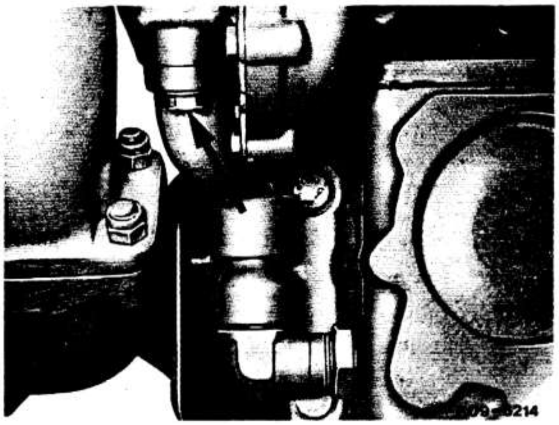
1 Remove exhaust pipe at flange elbow to turbocharger.

2 Unscrew air line at engine brake cylinder.

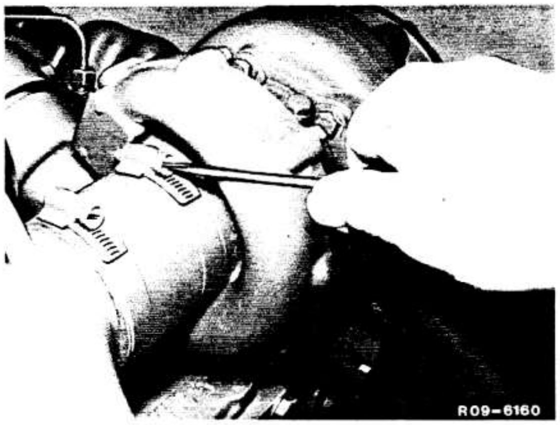
3 Detach oil delivery line (arrow).



4 Unscrew oil delivery line (arrow) at the turbocharger.

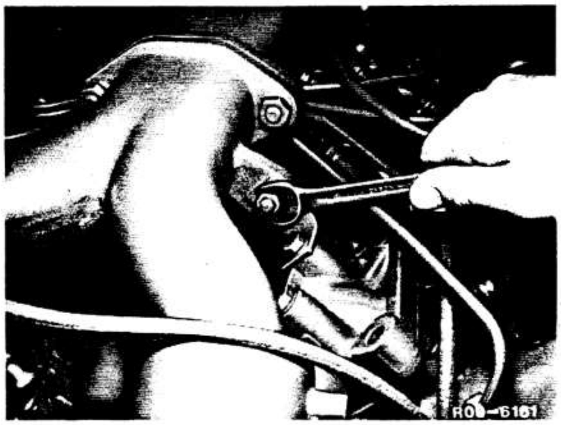


5 Remove charge air pipe between turbocharger and charge air cooler.



6 Remove charge air pipe between turbocharger and charge air cooler.

7 Unscrew turbocharger at exhaust manifold and remove.

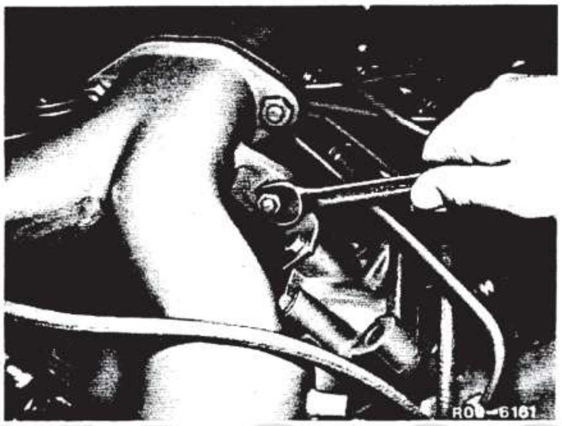


Installation

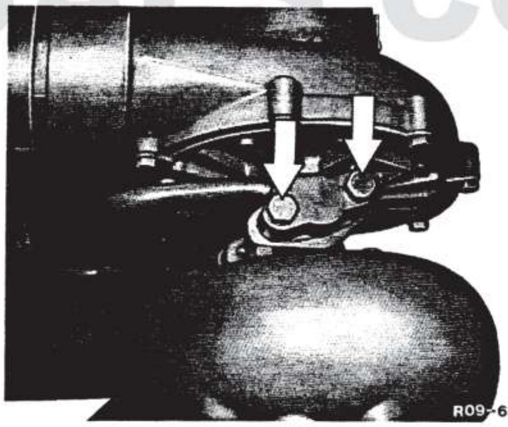
Note: Before installing the turbocharger, the intake line and the flange elbow ahead of the compressor, the exhaust manifold and the exhaust line as well as the oil supply and return lines must be very carefully checked for foreign bodies, dirt build-up and damage. The caps at the openings of the turbocharger should be removed only just before installation. Before connecting the oil supply line, the bearing housing must be filled with clean engine oil through the oil inlet hole. Turn rotating parts by hand to ensure an oil film forms on the bearings.

1 Mount turbocharger with new gasket on exhaust manifold and tighten to 50 Nm.

2 Install charge air tube or intake tube between exhaust turbocharger and charge air cooler and secure.

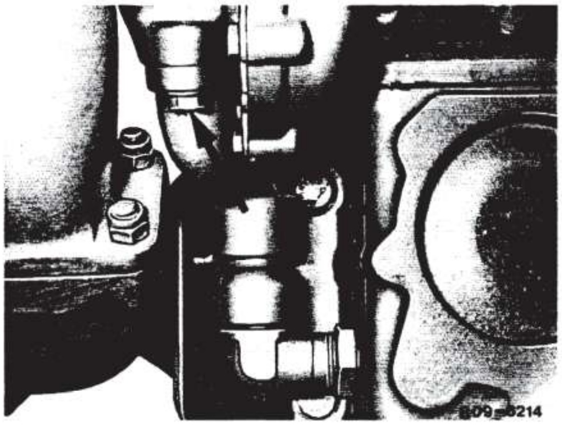


3 Attach oil delivery line (arrow).



4 Connect oil return line (arrow) to turbocharger.

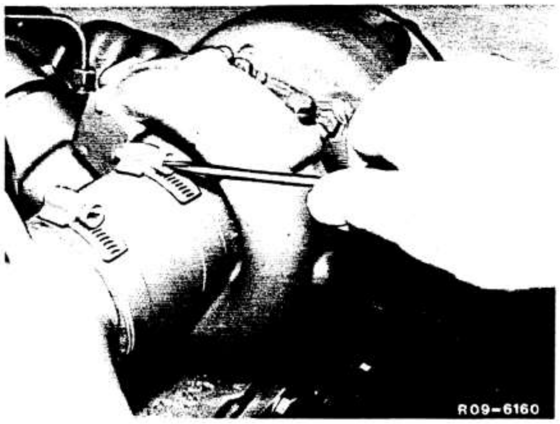
Note: The oil return on the left-hand side leads directly into the timing case via a pipe coupling. Note sealing rings.



5 Fit hose clips for air intake hose.

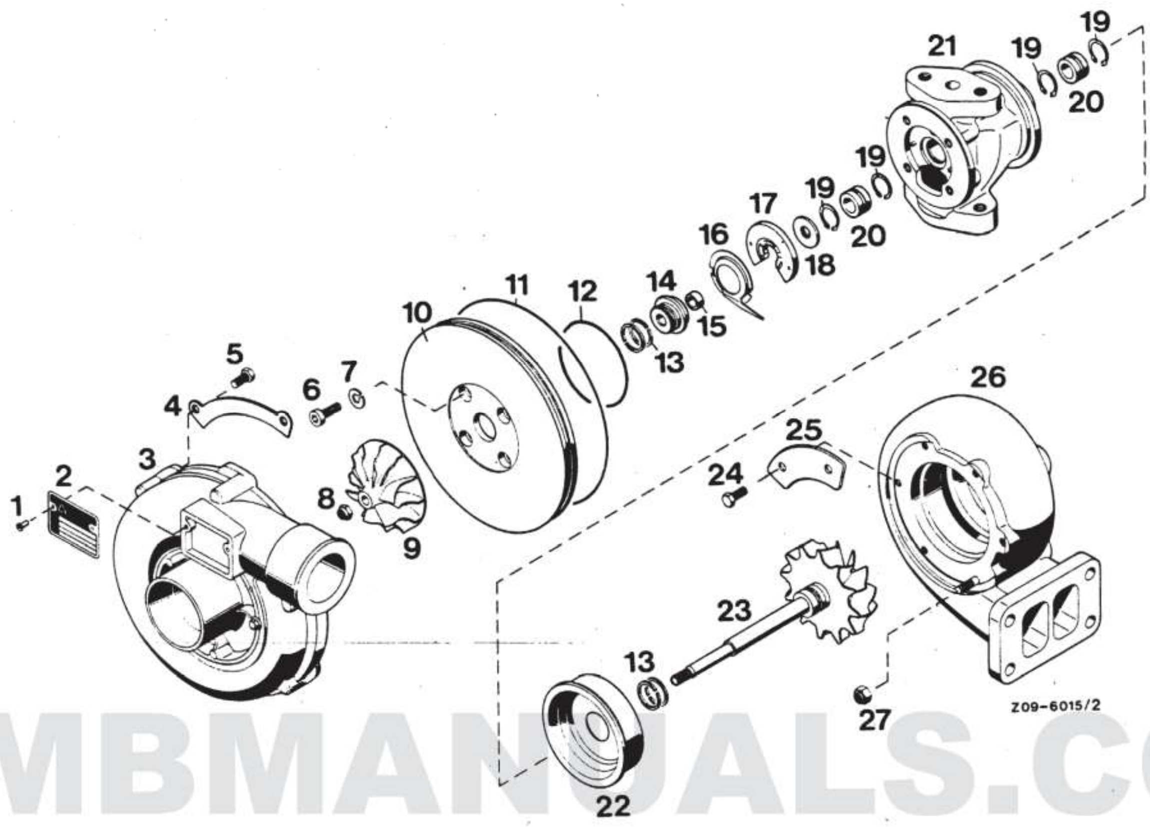
6 Attach air line at engine brake cylinder.

7 Secure exhaust pipe with gasket at flange elbow.



09 – 6263 Disassembly and Assembly of Turbocharger

Turbocharger removed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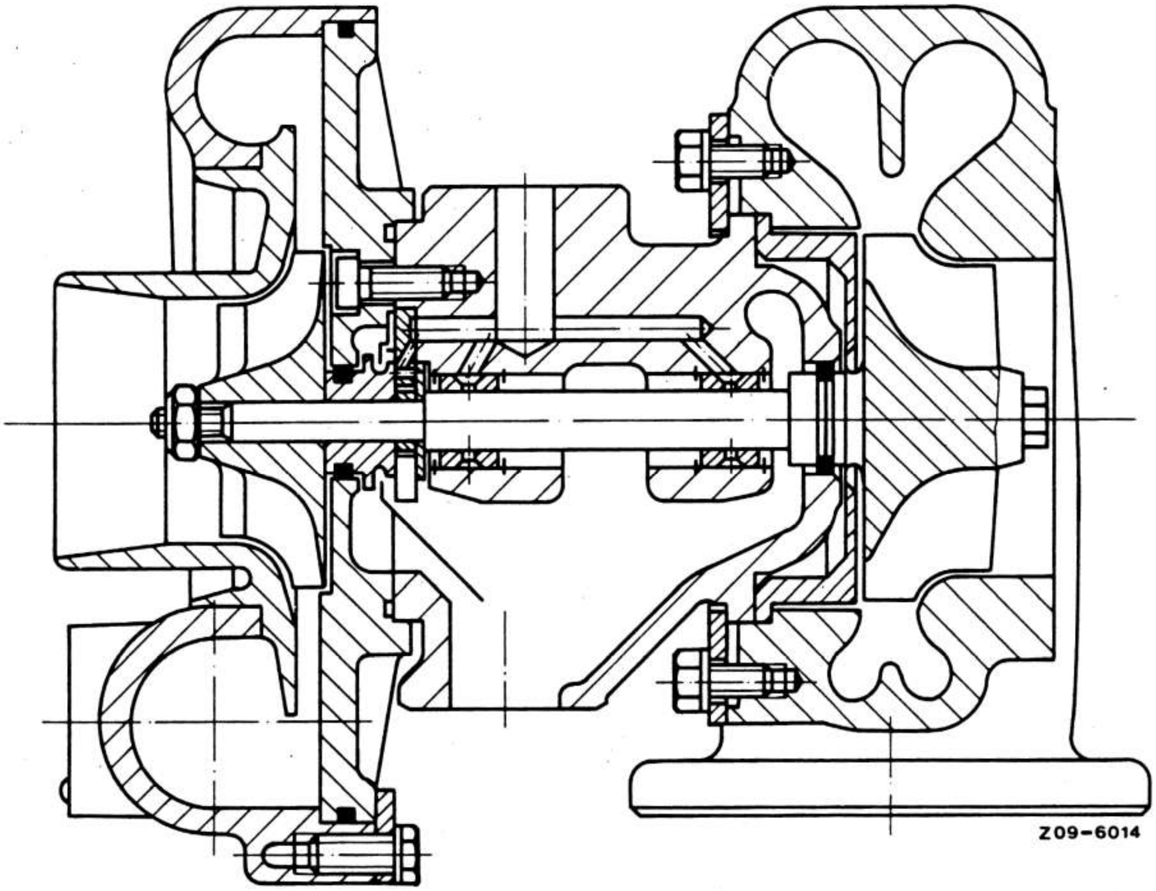
Z09-6015/2

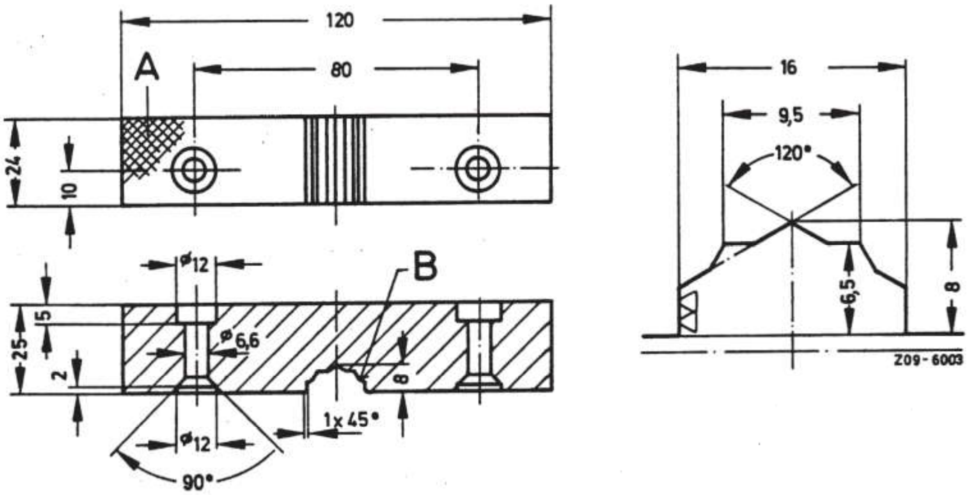
1	Stud	
2	Type identification plate	
3	Compressor housing	
4	Clamping segment for compressor housing	
5	Bolt	7 Nm
6	Bolt	8 Nm
7	Washer	
8	Shaft nut	12 Nm
9	Compressor wheel	
10	Rear panel	
11	O-ring	renew
12	O-ring	renew
13	Piston ring	
14	Packing bush	
15	Bush	
16	Oil guard	
17	Thrust bearing disc	
18	Bearing flange	
19	Retaining ring	
20	Bearing bush	
21	Bearing housing	
22	Heat shield	
23	Rotor	
24	Bolt	20 Nm
25	Clamping segment – turbine side	
26	Turbine housing	
27	Nut	20 Nm

Turbocharger



Workshop equipment

Hot air blower "Leister Gibli 2"		Supplier: Karl Leister CH-6056 Kägiswil
Insert	Order No. 1/991-6	Supplier: Hazet D-5630 Remscheid



Z09-6003

Jaws

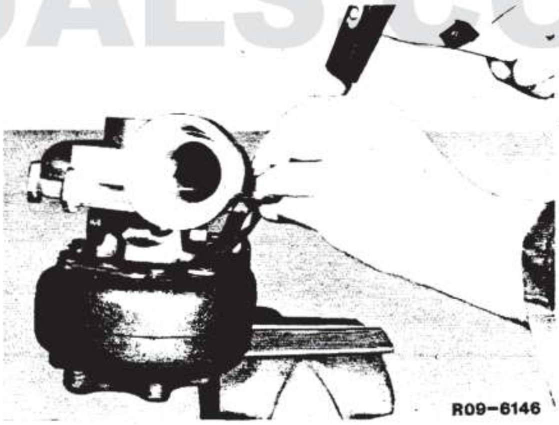
A Knurling
B Fitted in existing rotor

Disassembly

Note: The clamping jaws are self-made (see drawing).

1 Mark position of turbine housing with respect to bearing housing.

2 Release retaining tab at the clamping segments of turbine housing.

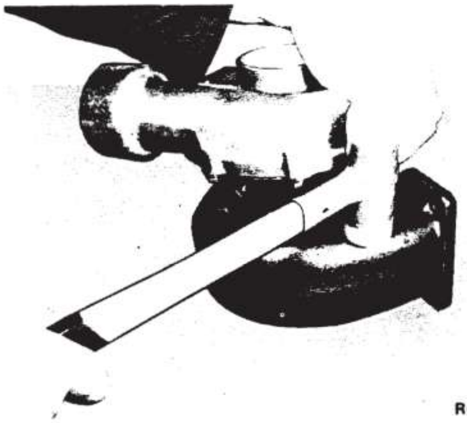


R09-6146

3 Loosen bolts holding the turbine housing and remove together with clamping segments and retaining tab.

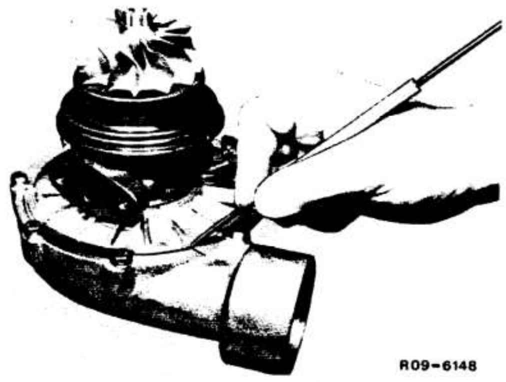
4 Using a soft-headed hammer, knock the turbine housing from the bearing housing.

Note: Take particular care when releasing the turbine housing to ensure the blades of the charger shaft are not damaged.



R09-6147

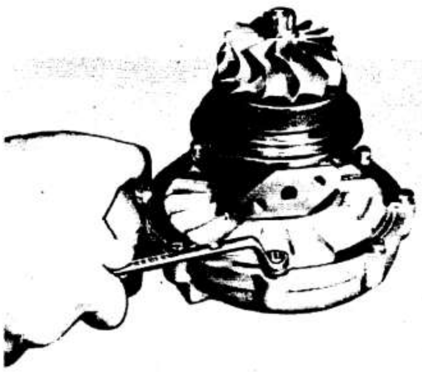
5 Mark position of bearing housing with respect to the rear wall of the compressor and the rear wall of the compressor to the compressor housing.


R09-6148

6 Unscrew compressor housing from the compressor rear wall.

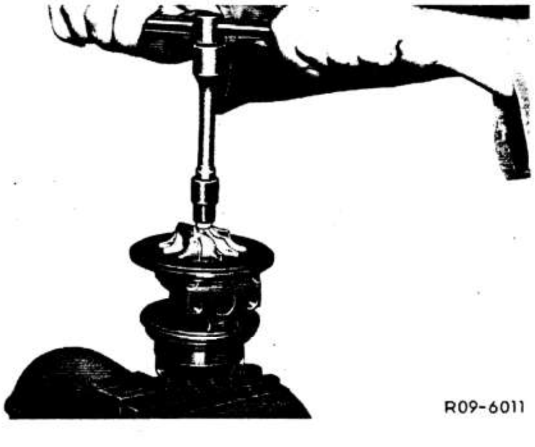
7 Using a soft-headed hammer, release the compressor housing with light hammer blows from the bearing housing and remove.

Note: Take particular care when releasing the compressor housing to ensure that the blades of the compressor wheel are not damaged.


R09-6149

8 Clamp rotor at the hub and unscrew shaft nut.

Note: When loosening the shaft nut, take care not to damage the rotor by twisting it. Always use a T-socket wrench to loosen the shaft nut, thus ensuring no bending moments act on the rotor.

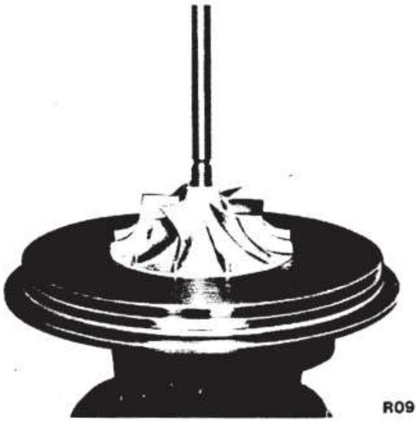

R09-6011

9 Heat the compressor wheel with a hot air blower.

R09-6120

10 Press the rotor shaft out from compressor wheel.

Note: Correctly center heat shield to avoid damage to the piston rings and heat shield.



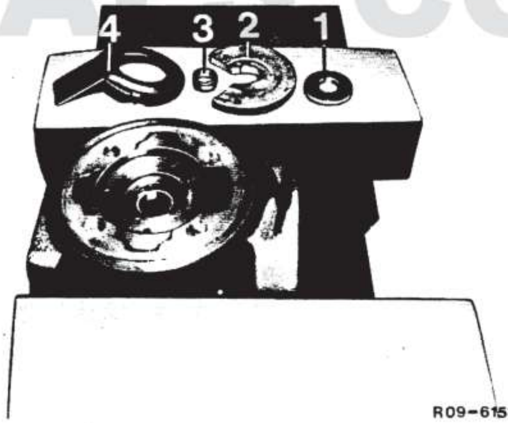
R09–6121

11 Unscrew compressor rear wall and remove together with packing push and O-ring.

12 Remove bearing housing and heat shield from the rotor shaft.

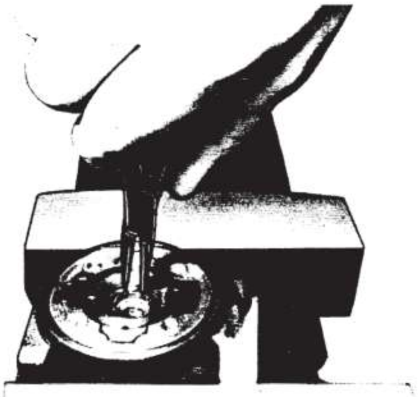
R09–6150

13 Remove oil guard (4), bush (3), thrust bearing disc (2) and bearing flange (1).



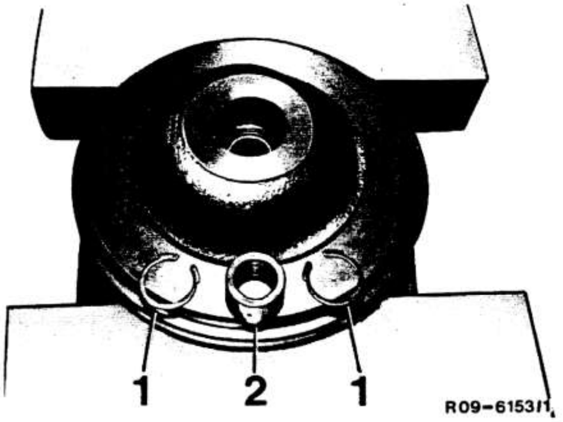
R09–6151

14 Remove bearing bush on the compressor side from the bearing housing.



R09–6152

15 Remove snap ring (1), bearing bush on the turbine side (2) and snap ring (1) from the bearing housing.

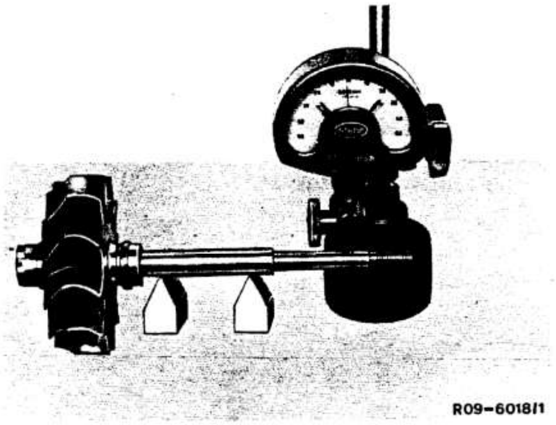


R09-6153/1

Assembly

Note: Clean all parts and check for damage. Check housing and wheels for cracks, foreign bodies and scoring marks. Check piston ring seals for wear. Examine wheels for bent and broken blades.

1 Check concentricity of rotor shaft. Place rotor shaft on two V-blocks at the height of the bearing points and check concentricity with a dial gauge at 20 mm from the end of the rotor.
Permissible runout 0.007 mm.

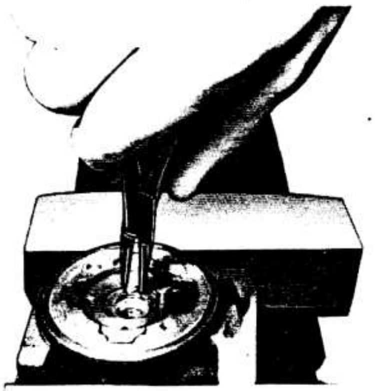


R09-6018/1

2 Insert retaining ring in the bearing housing, oil bearing bush on the turbine side, insert and fit second retaining ring.

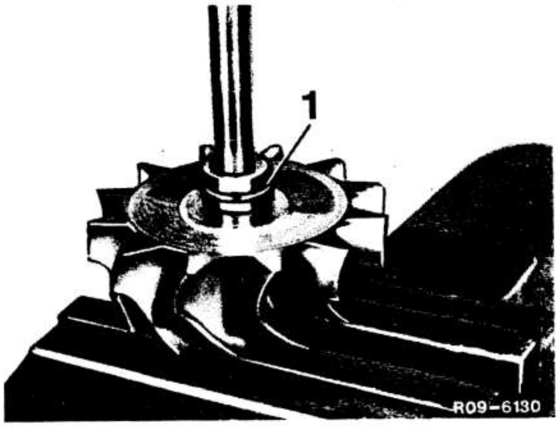
Note: The retaining rings must be fitted such that the rounded side faces towards the bearing.

3 Overturn bearing housing and install bearing bush on the compressor side with retaining rings.

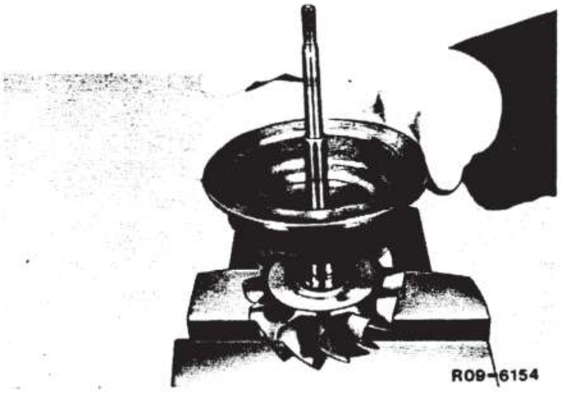


R09-6152

4 Mount piston rings (1), offset by 180°, on the rotor shaft and center.



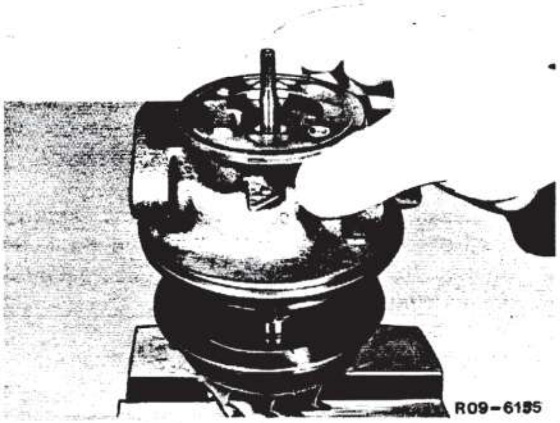
5 Place heat shield over the piston rings on the rotor shaft.



R09-6154

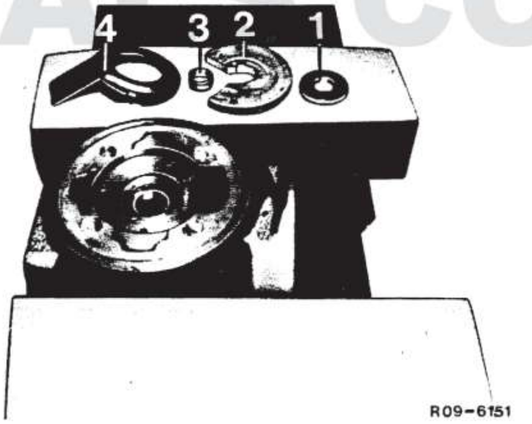
6 Mount bearing housing over the piston rings and onto the rotor shaft in such a way that the flange surfaces for the oil supply and return line are positioned at 90° with respect to the relevant piston ring gap.

Note: The heat shield must still turn freely after fitting the bearing housing.



R09-6155

7 Insert bearing flange (1) and bush (3). Fit thrust bearing (2) with the oil groove facing towards the bearing housing and such that the holes are clear in the centering pins. Mount oil guard (4).

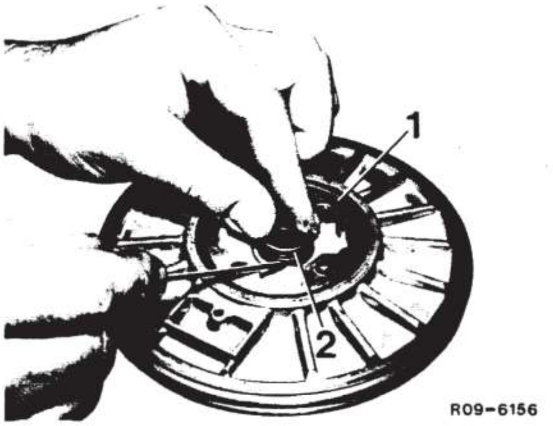


R09-6151

8 Grease O-ring with brake cylinder paste and fit in compressor rear wall.

9 Mount piston rings on sealing bush offset by 180°.

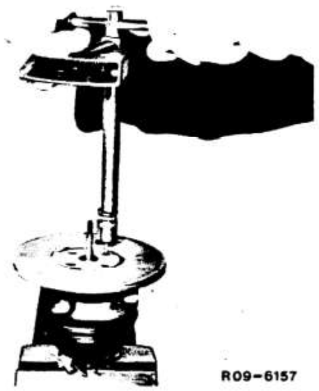
10 Insert sealing bush with piston rings in the compressor rear wall such that the flange surfaces for the oil supply and return line are positioned 90° with respect to the relevant piston ring gap.



R09-6156

11 Coat sealing surface between bearing housing and compressor rear wall with sealing compound 001 997 37 20.

12 Mount compressor rear wall in accordance with the marking to the bearing housing, coat securing bolts with Loctite 640, screw in and tighten to 8 Nm. Firmly hold bearing body when tightening the bolts.

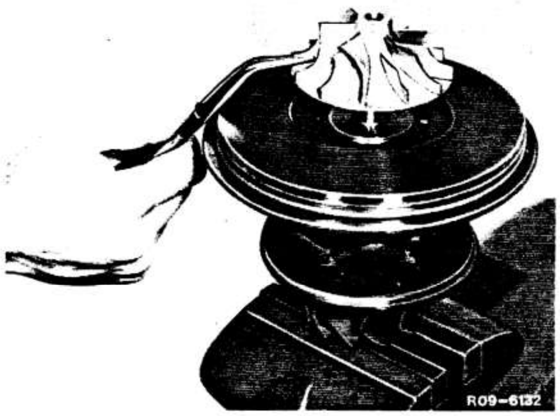


R09-6157

13 Place O-ring on the compressor rear wall.

R09-6158

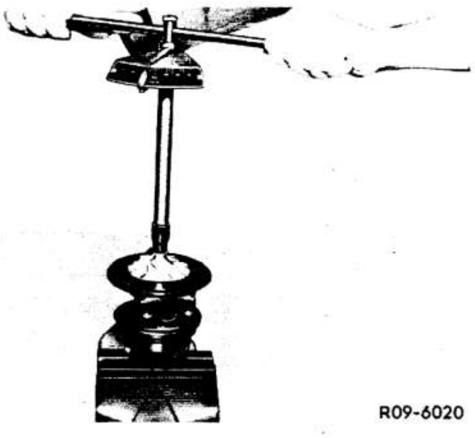
14 Heat compressor wheel on a hotplate to a maximum temperature of 130° C and fit on the rotor shaft.



R09-6132

15 Coat shaft nut with Loctite 640, fit and tighten to 12 Nm.

Note: Take particular care when tightening the shaft nut to ensure that the rotor is not damaged by twisting.



R09-6020

16 Mount compressor housing in accordance with the marking to the compressor rear wall. Fit clamping elements and tighten securing bolts cross wise to 7 Nm.

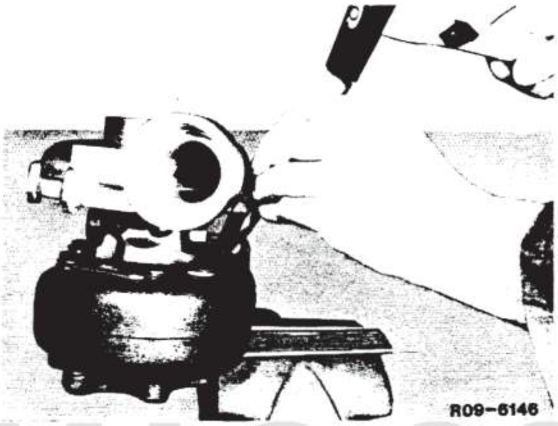
R09-6149

17 Mount turbine housing in accordance with marking to bearing housing, fit clamping segments and retaining taps. Coat securing bolts with hot lubricating paste and tighten crosswise to 20 Nm.

18 Lock securing screw.

19 Check that turbocharger shaft runs smoothly.

Note: The bearing housing must be filled with engine oil via the oil supply hole before putting the turbocharger into operation.



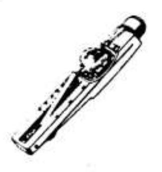
R09-6146

13 – 1402 Renewing V-Belts

Data

V-belt tension in N	new used	400–500 300–400

Special tools

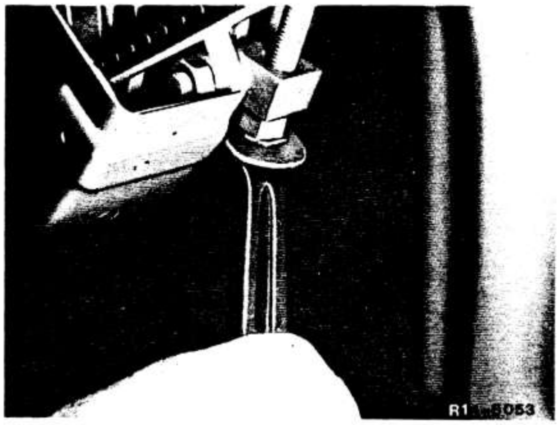


001 589 69 21 00

Renewing V-belts

1 Release clamping screw at the alternator.

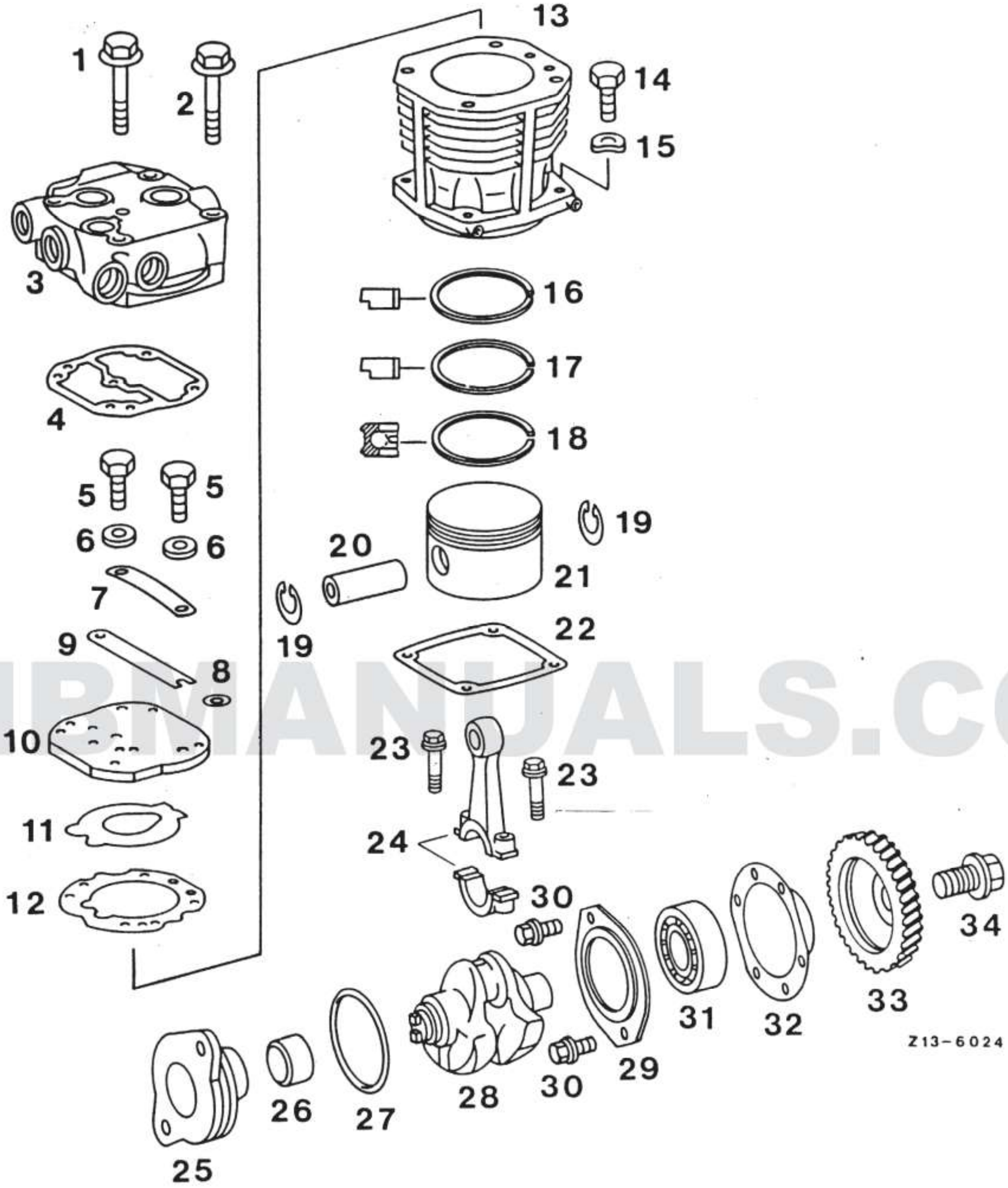
2 Relief tension of V-belt and remove over the pulley.



3 Fit V-belt and tension.

4 Check V-belt tension with special tool

Tension measuring unit 001 589 69 21 00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Z13–6024

1	Bolt, intermediate plate	30 Nm
2	Bolt, cylinder head	30 Nm
3	Cylinder head	
4	Gasket	renew
5	Bolt	15 Nm
6	Spring washer	
7	Bracket	
8	Bolt	

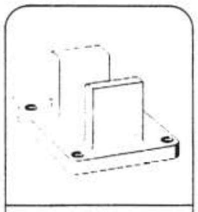
9	Pressure disc	
10	Intermediate plate	
11	Intake disc	
12	Gasket	renew
13	Cylinder liner	
14	Bolt	30 Nm
15	Spring washer	
16	Piston ring	
17	Piston ring	
18	Piston ring	
19	Retaining ring	
20	Piston pin	
21	Piston	
22	Gasket	renew
23	Connecting rod bolt	30 Nm
24	Connecting rod	
25	Flange	
26	Bush	
27	Sealing ring	renew
28	Crank shaft	
29	Bearing cap	
30	Bolt	50 Nm
31	Roller bearing	
32	Mounting flange	
33	Drive gear	
34	Bolt	tighten with special wrench 442 589 00 03 00 to 270 Nm. This corresponds to an actual value of 360 Nm.

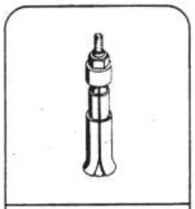
Data

Bore diameter		90.030 89.990
Piston diameter		89,950 89.910
Piston clearance		0.082 0.102
Piston setback from upper edge of cylinder liner		0.61
Piston projection from upper edge of cylinder liner		0.22
Piston pin diameter		20.000 19.995
Piston pin clearance – connecting rod		0.020 0.038
Piston pin clearance – piston		0.003 0.012
Crankshaft journal diameter		31.975 31.959
Piston ring gap clearance	Groove I Groove II Groove III	0.20 0.80
Piston ring vertical clearance	Groove I Groove II	0.20 0.45
	Groove III	0.20 0.55

Tightening torques	Nm
Power steering pump to timing case	60
Bearing cover to timing case	25

Special tools


403 589 01 63 00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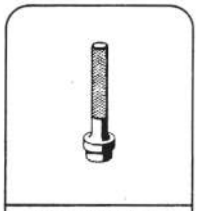
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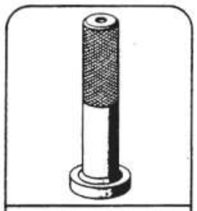
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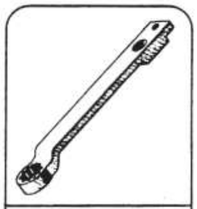
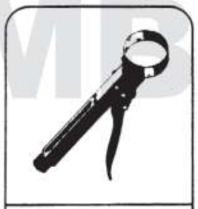

442 589 00 03 00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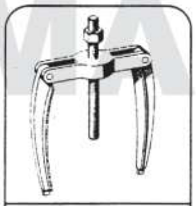
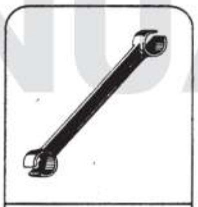

000 589 34 33 00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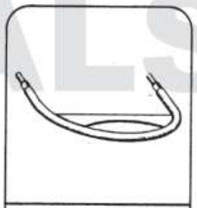
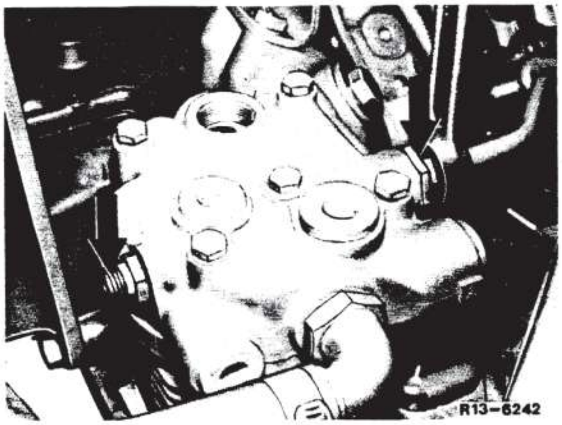

403 589 05 63 00

Disassembly

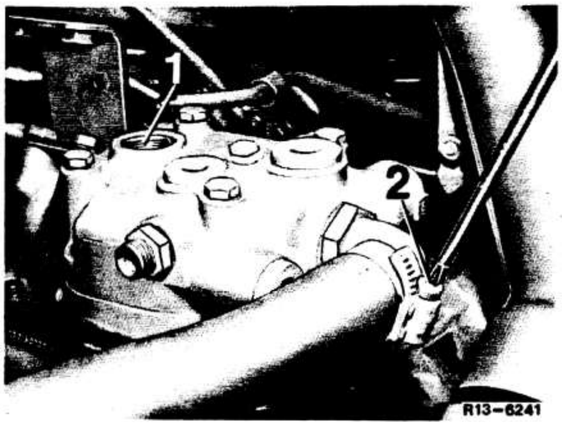
1 Unscrew coolant supply and return line (arrow) with special wrench.

Special wrench 000 589 07 03 00



2 Detach compressed air line (1) at cylinder head.

3 Detach intake line (2) at cylinder head.

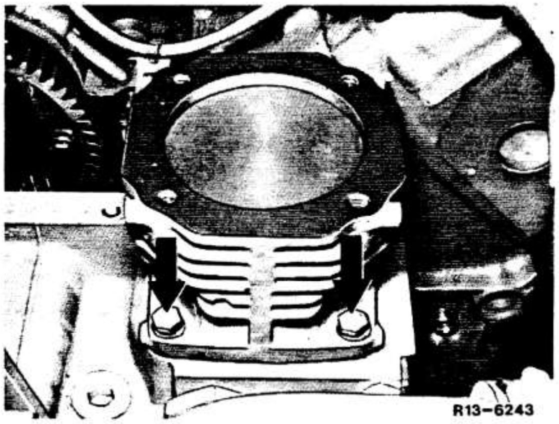


4 Remove timing case cover.

5 Remove end cover on timing case.

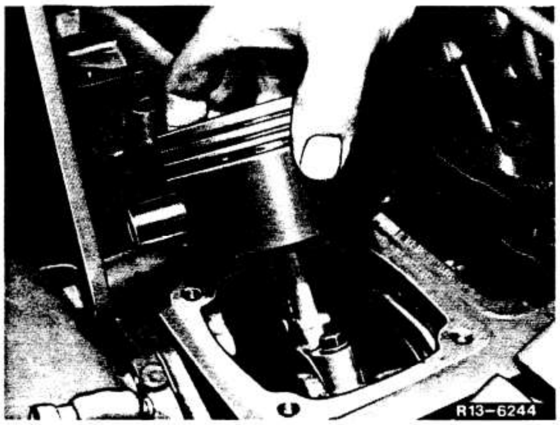
6 Unscrew compressor cylinder head and remove with intermediate plate.

7 Unscrew cylinder liner from timing case (arrow) and remove over the piston.

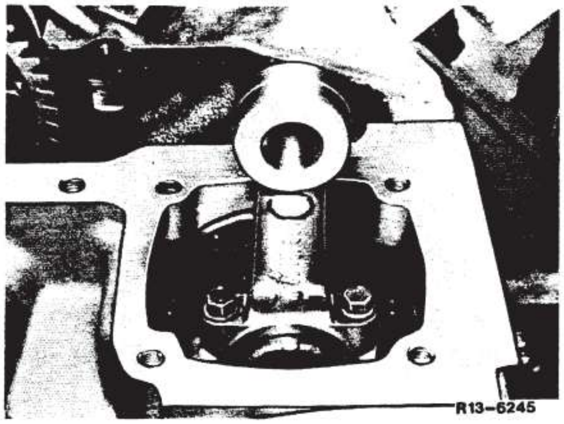


8 Remove retaining ring for piston pin.

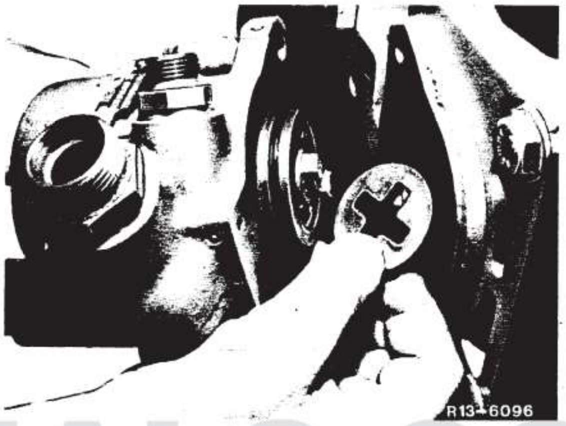
9 Press out piston pin and remove piston.



10 Detach connecting rod and remove together with bearing cap and bearing shells.



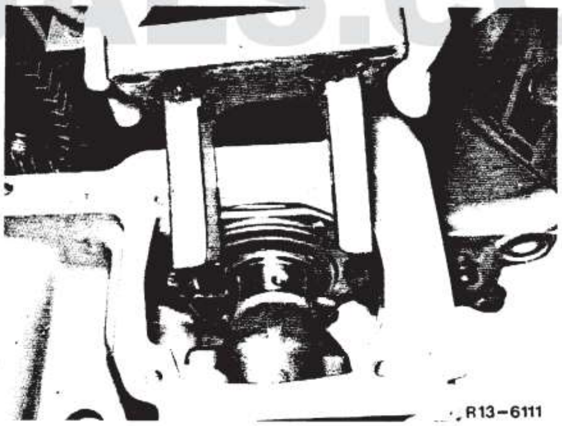
11 Detach power steering pump and remove driver disc.



12 Place blocking fixture over the crankshaft and tighten.

Note: The crankshaft must be turned until the journal faces upwards.

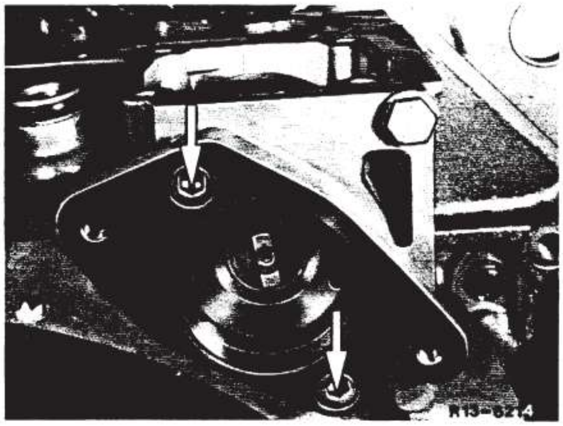
Blocking fixture 403 589 01 63 00



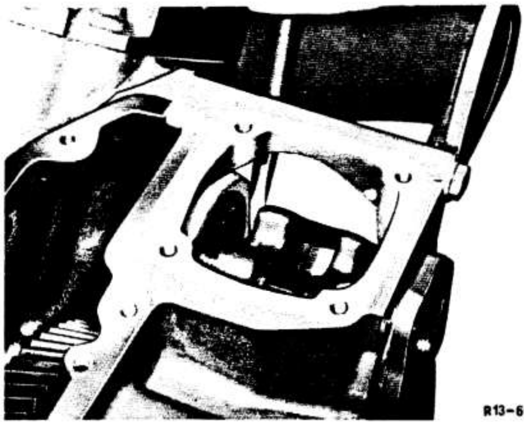
13 Unscrew drive gear with special tool and remove.

14 Detach blocking fixture and remove.

15 Unscrew socket head cap screws for rear bearing flange (443 LA).

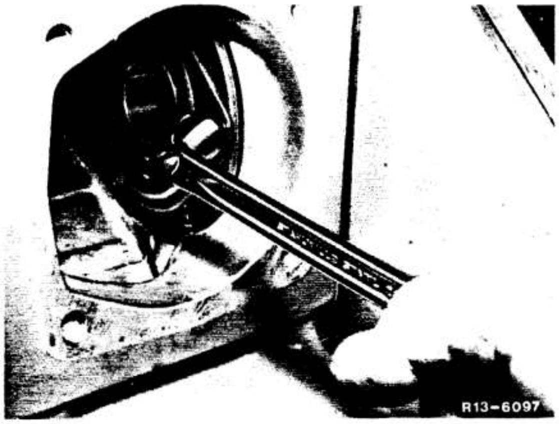


16 With the aid of a crowbar, press the crankshaft out of the bearing such that the rear bearing flange can be removed. Withdraw the crankshaft from the housing through the upper opening.



R13-6004

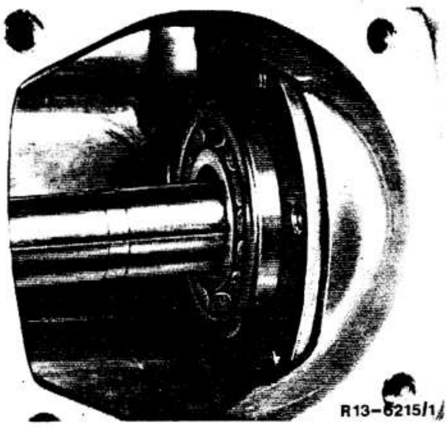
17 Remove retaining ring for roller bearing.



R13-6097

18 Remove roller bearing with special tool and self-made support plate.

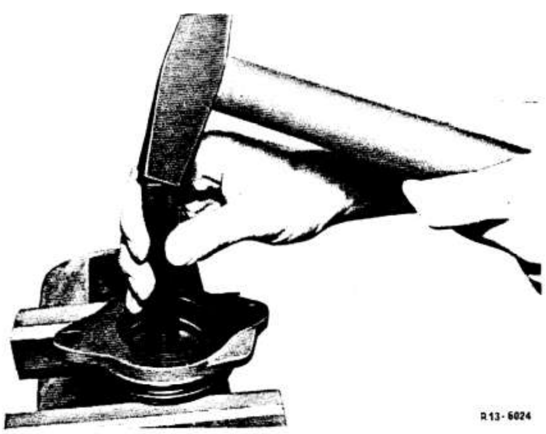
Internal extractor	000 589 28 33 00
Spindle from countersupport	000 589 34 33 00



R13-6215/1

19 Using the special tool, knock out the bearing bush from the bearing flange.

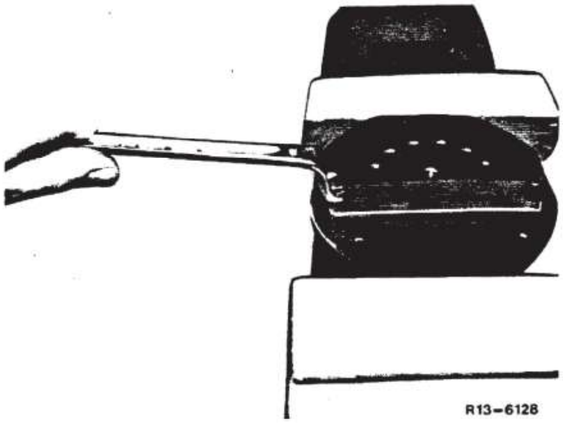
Drift 363 589 03 15 00



R13-6024

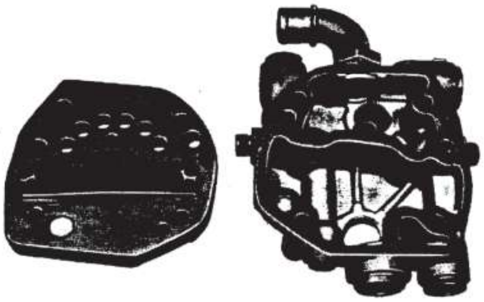
20 Unscrew intermediate plate from cylinder head and remove.

21 Remove pressure valve disc from the intermediate plate.

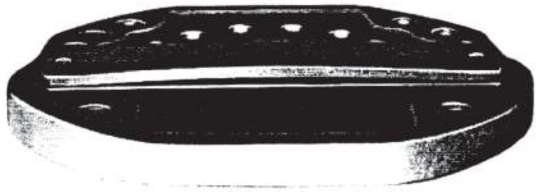

R13-6128

Assembly

1 Place the pressure valve disc on the intermediate plate and insert ring in the recess of the pressure disc.


R13-6246

2 Place valve plate – arch facing upwards – on the pressure disc and tighten to 15 Nm.


R13-6100

3 Fit intermediate plate with new gasket on the cylinder head and tighten to 30 Nm.

4 Drive in bearing bush in the bearing flange with the special tool and with a reamer ream out to the size $\frac{30.041}{30.020}$

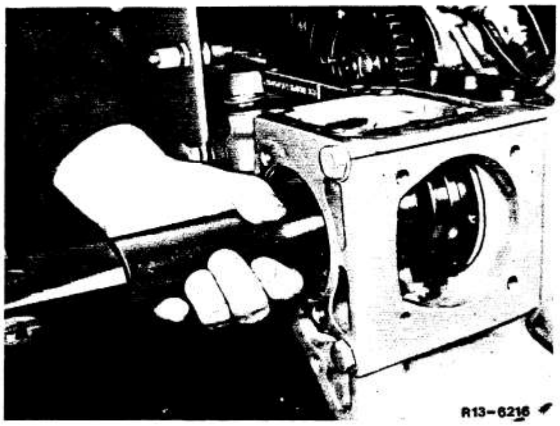
Note: Take particular care to ensure that the oil holes in the bearing bush agree with the bearing flange (arrow).

Drift 363 589 03 15 00

R13-6025/1

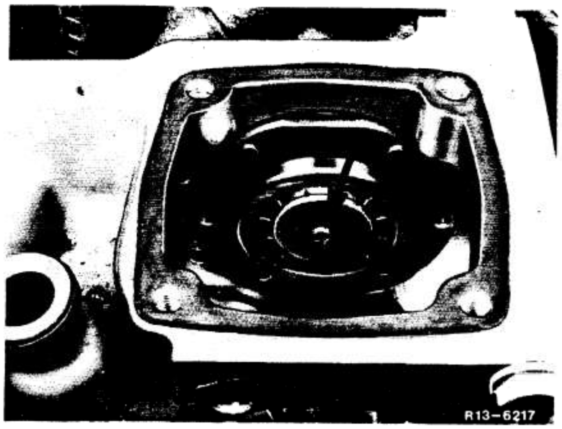
5 Install bearing in bearing cover.

Drift 198 589 03 39 00

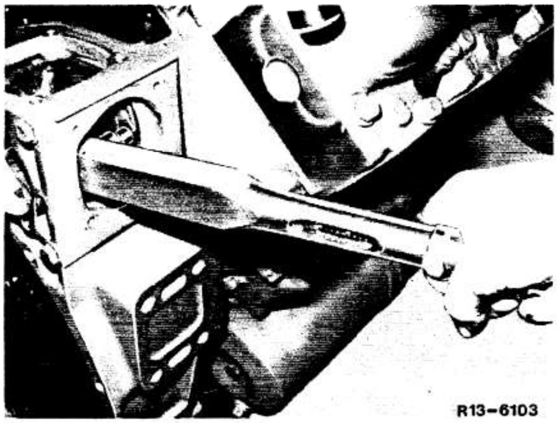


Note: Before installation, secure roller bearing with two tap washers and 1 bolt (arrow) to prevent it falling apart. Loose bearing ring facing in the direction of the crankshaft.

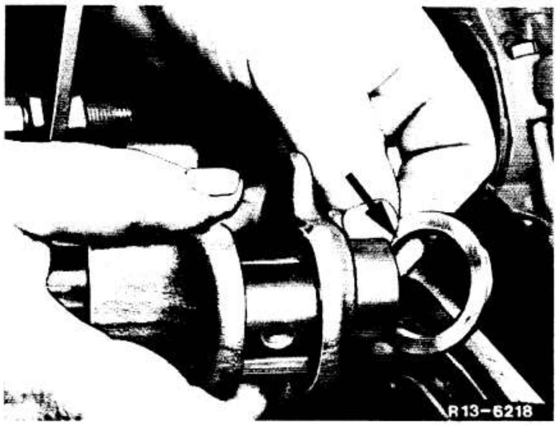
Drift 198 589 03 39 00



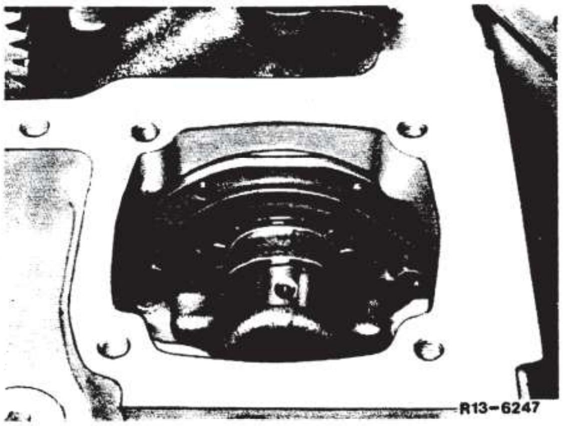
6 Mount retaining ring for bearing and tighten securing bolts to 50 Nm.



7 Remove bolt and tab washers once again. Place loose bearing ring on the crankshaft with the chamfer (arrow) facing towards the shaft journal.
Mount crankshaft while holding the inner ring of the roller bearing.

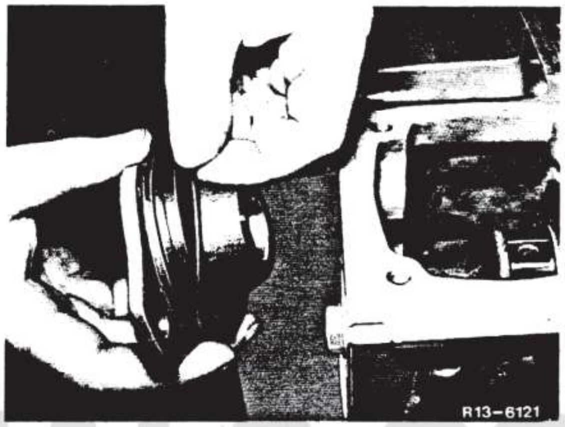


8 Install crankshaft.



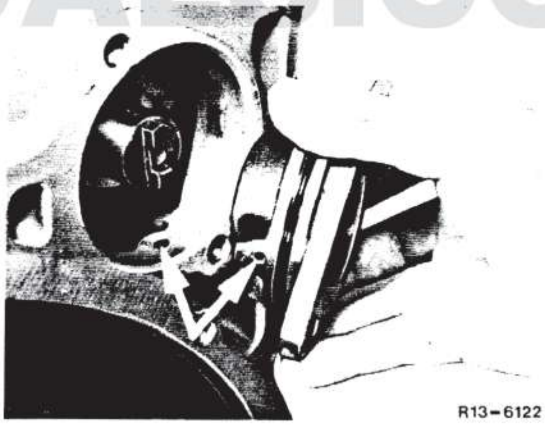
R13-6247

9 Place gasket on bearing flange.



R13-6121

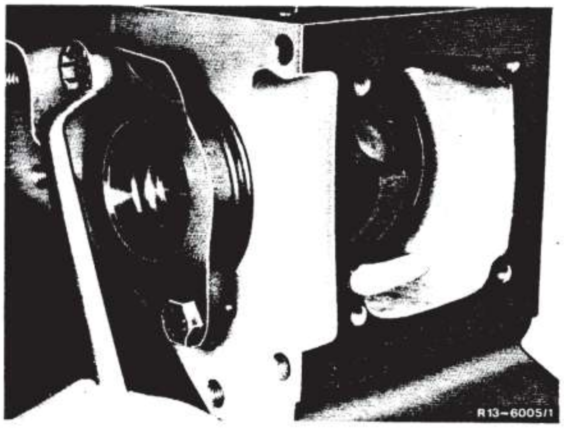
10 Coat bearing flange on the fit surface and O-ring with oil, place on the housing and on the crankshaft. Ensure the oil holes in the housing are aligned with the holes in the bearing flange.



R13-6122

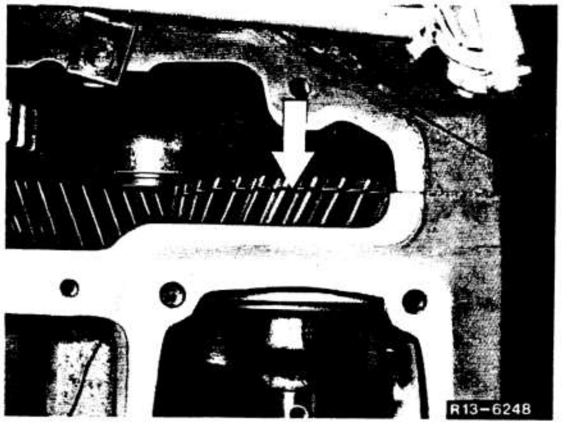
11 Screw in bolts and uniformly tighten bearing flange.

12 Remove bolts once again.



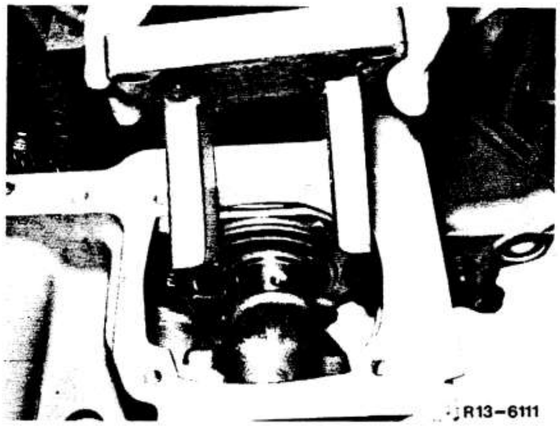
R13-6005/1

13 Mount drive gear (arrow) for compressor and fit securing screw.



14 Attach blocking fixture for the crankshaft and secure.

Blocking fixture 403 589 01 63 00

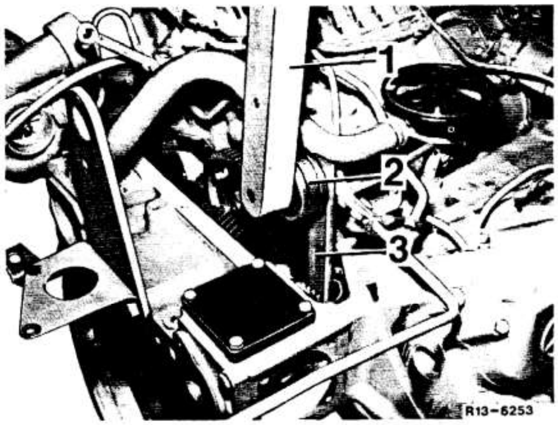


15 Tighten securing bolt with special tool to 270 Nm.

Note: This value corresponds to an actual torque of 360 Nm.

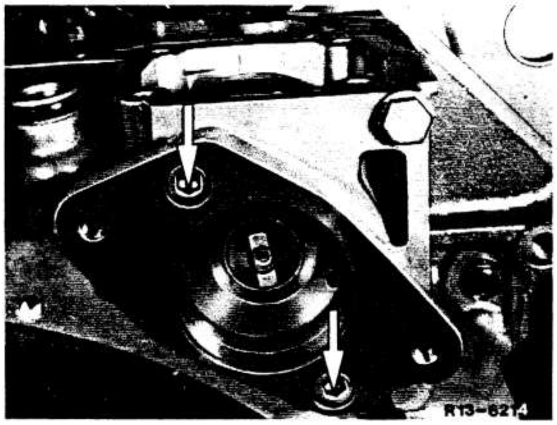
The torque wrench (1) with ratchet (2) and socket insert (3) must be positioned in one line with respect to each other.

Socket insert (3) 442 589 00 03 00

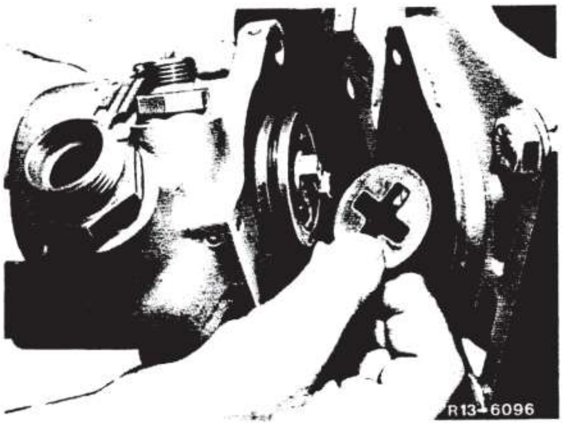


16 Remove blocking fixture.

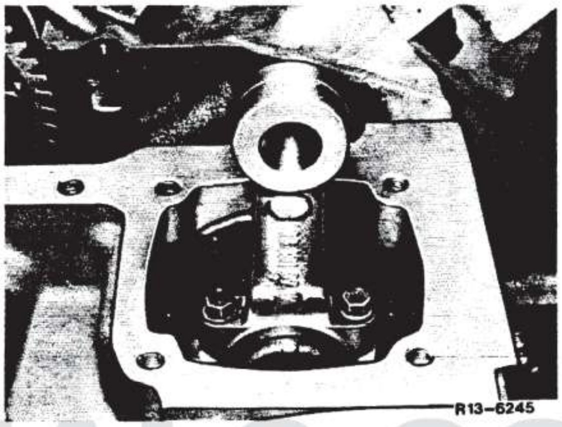
17 Mount rear bearing flange.



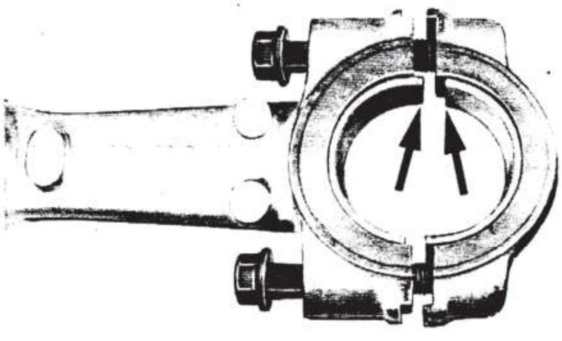
18 Fit power steering pump and tighten to 60 Nm.



19 Install connecting rod together with bearing cap and bearing shell. Tighten connecting rod bolts to 30 Nm.

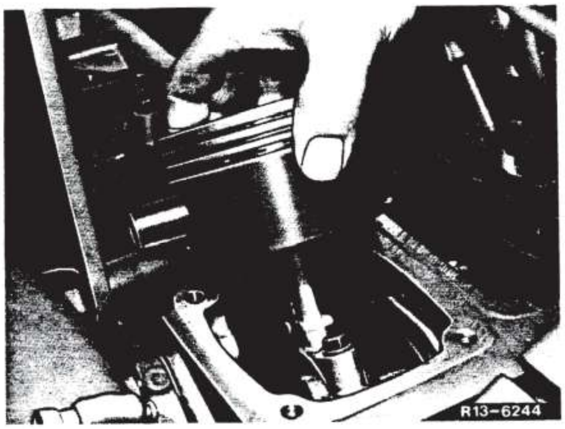


20 **Note:** The long side of the big end bearing in the connecting rod must agree with the short side of the big end bearing in the bearing cap.

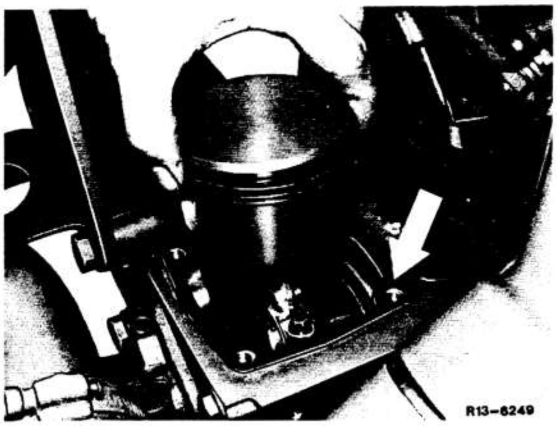


21 Place piston over the connecting rod and fit piston pin.

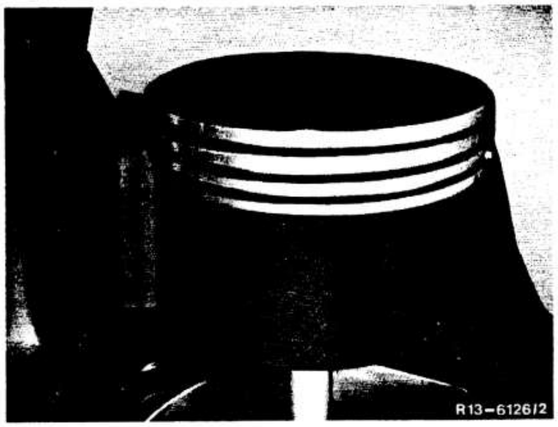
22 Secure piston pin.



23 Fit gasket (arrow) for cylinder liner.



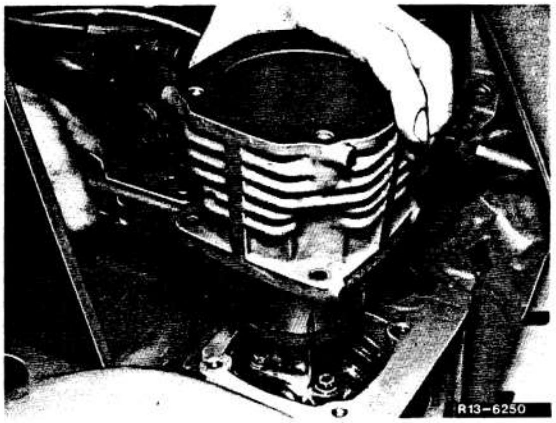
24 Piston ring gaps offset by 180°.



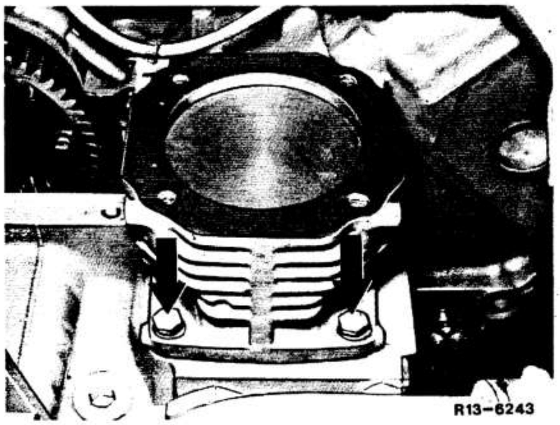
25 Compress piston rings with special tools until the ring compressor can still just be moved.

26 Place cylinder liner over the piston and press in.

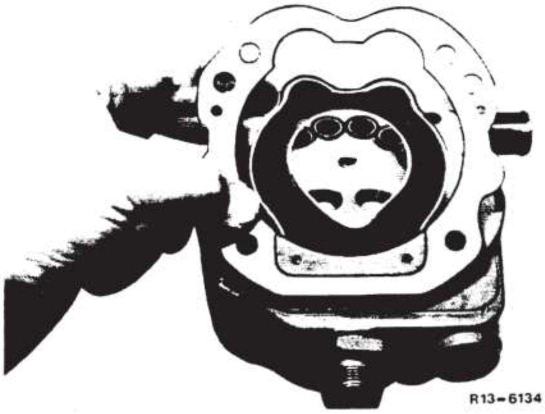
Ring compressor 000 589 20 61 00



27 Bolt cylinder liner (arrow) to timing case and tighten to 25 Nm.

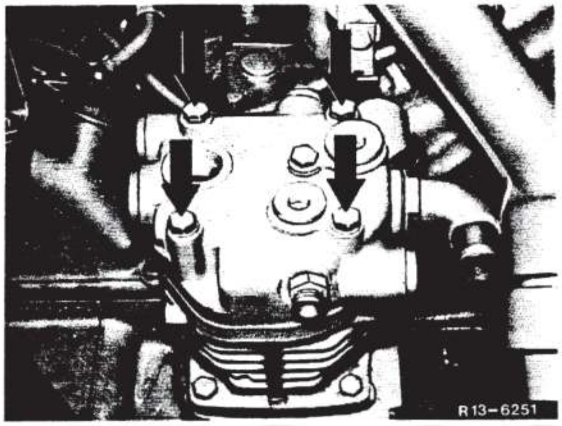


28 Place intake valve disc and cylinder head gasket – the word "top" facing in direction of the intake valve disc – over the lock pins on the cylinder head.



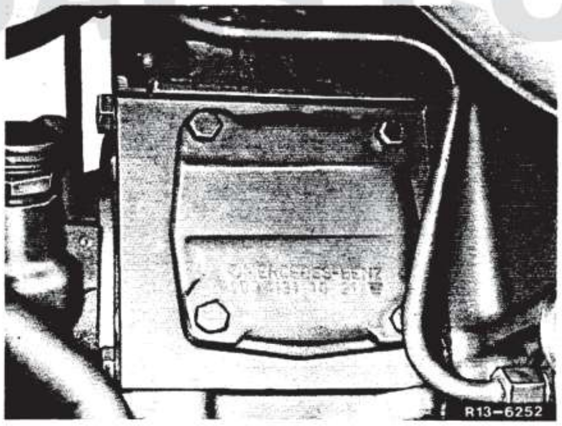
R13–6134

29 Bolt cylinder head (arrow) to the cylinder liner and tighten to 30 Nm.



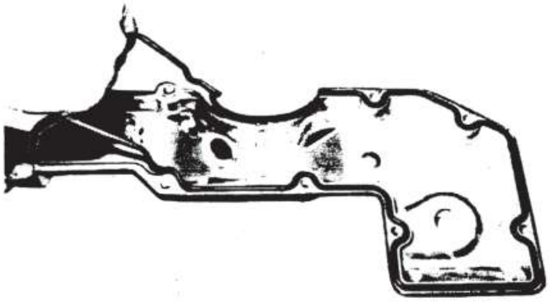
R13–6251

30 Mount end cover and gasket on timing case and tighten to 25 Nm.



R13–6252

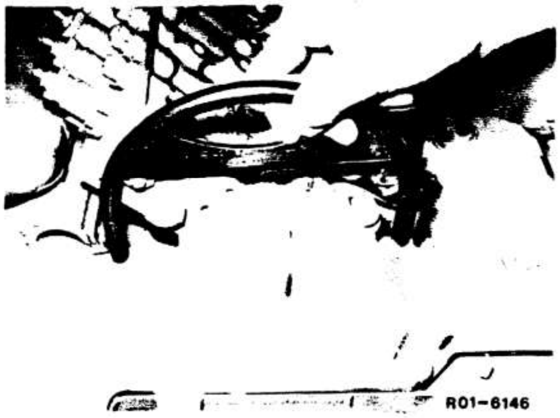
31 Fit gasket in timing case cover.



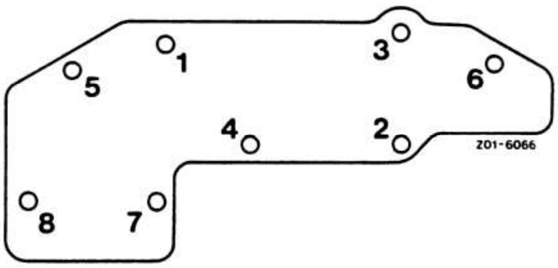
R01–6136

32 Fit timing case cover and locate with special tool.

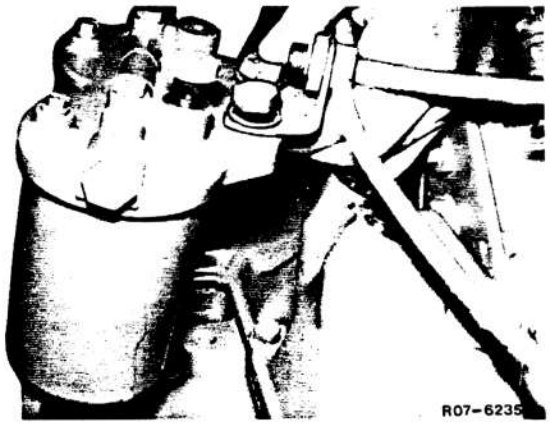
Assembly tool 403 589 05 63 00



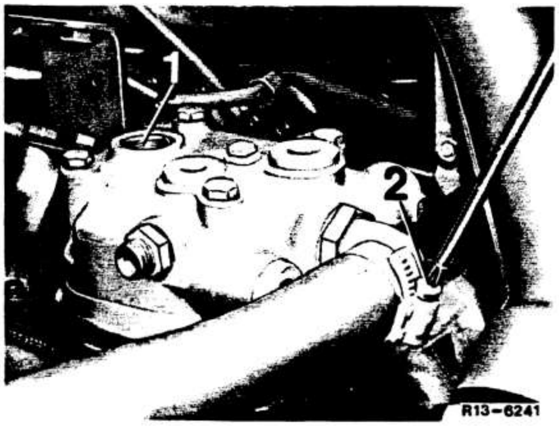
33 Tighten the timing case cover to 25 Nm in the sequence shown in the bolt tightening diagram.


1
3
5
6
4
2
8
7
Z01-6066

34 Tighten fuel filter to 80 Nm on the timing case cover.



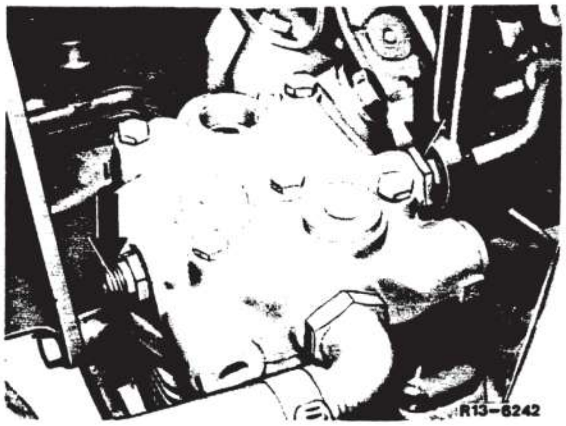
35 Attach intake line (2) and delivery line (1) on the cylinder head.



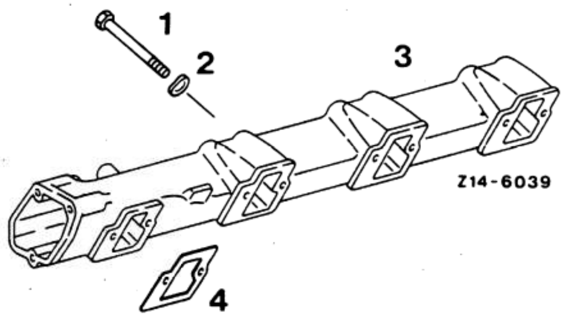
36 Screw on coolant supply and return line (arrow) with special tool.

37 Install turbocharger on right and exhaust manifold.

Box wrench 000 589 07 03 00

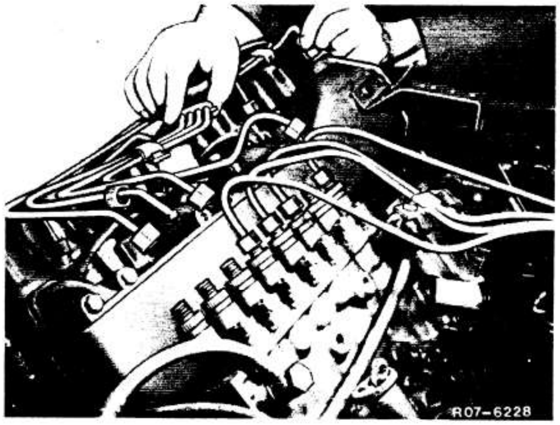


14 – 0053 Removal and Installation of Intake Manifold



1	Bolt	30 Nm
2	Spring washer	
3	Intake manifold	
4	Gasket	renew

Removal



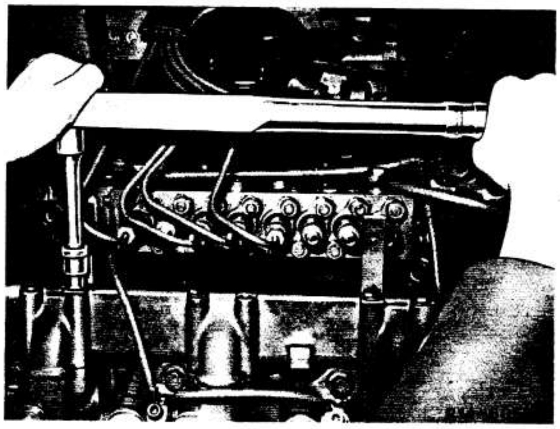
1 Unscrew injection lines to the relevant row of cylinders and remove.

2 Remove cross intake pipe at the intake manifold.

3 Remove intake hose to compressor.

4 Unscrew intake manifold and remove.

Installation



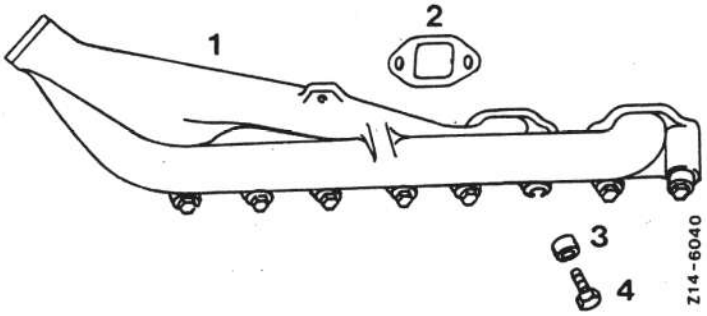
1 Mount intake manifold with new gaskets and tighten to 30 Nm.

2 Fit cross intake pipe.

3 Mount intake hose to the compressor.

4 Fit injection lines.

14 – 0068 Removal and Installation of Exhaust Manifold



1	Exhaust manifold	
2	Gasket	renew
3	Sleeve	
4	Bolt	50 Nm

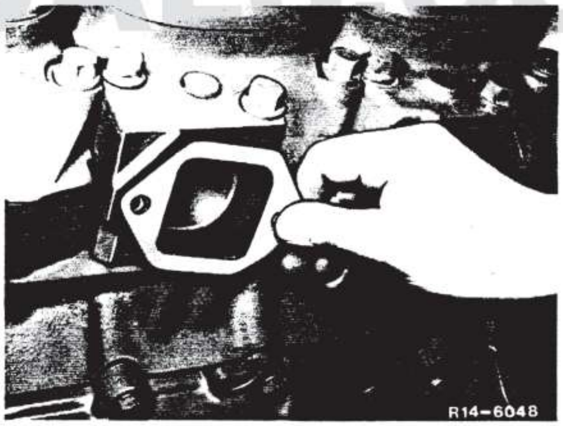
Removal

1 Unscrew exhaust pipe at the exhaust manifold.

2 Detach engine brake cylinder.

3 Unscrew exhaust manifold and remove.

4 Remove gaskets.


R14-6048

Installation

1 Mount exhaust manifold with new gaskets.

2 Screw in securing bolts with sleeves and tighten to 50 Nm.

3 Attach engine brake cylinder and secure.

R14-6049

4 For engine 443 LA: Mount steel sealing rings on intermediate piece for exhaust manifold.

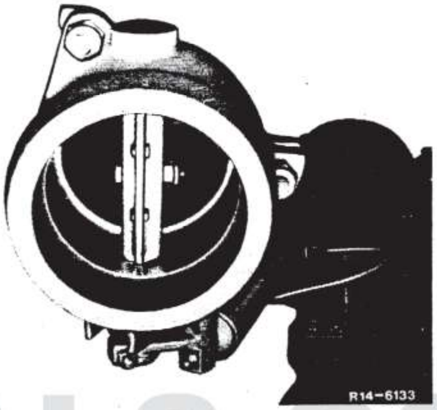
5 Mount exhaust pipe on exhaust manifold.

R14–6129

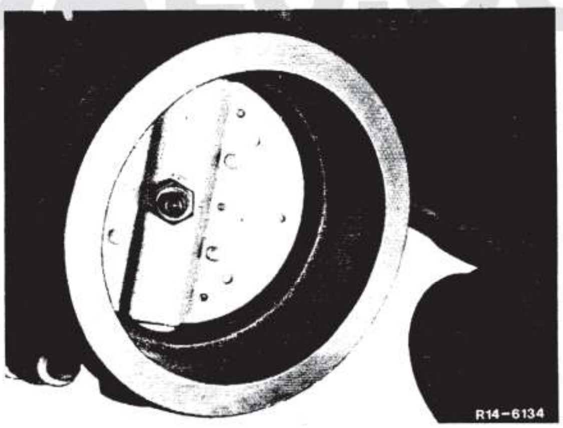
Setting engine brake setting

1 Unscrew exhaust pipe at the exhaust manifold.

2 Check whether the engine brake valve is completely open when the engine brake is not activated and the marking on the engine brake shaft agrees with the engine brake flap valve.



3 Operate engine brake and check whether the engine brake flap valve is completely closed.



14 – 0120 Setting Engine Brake

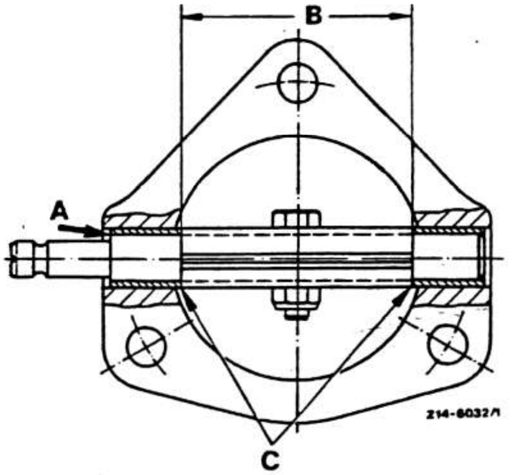
I Naturally aspirated engine

1 A Shaft shoulder and upper edge of bush on one level when pressing in.

Press in the bush until the lower shoulder of the shaft comes in contact with the second bush.

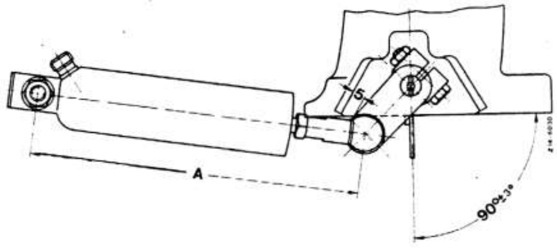
B Permissible deviation in center alignment from distance B to inside diameter of the manifold 0.2 mm.

C The built-in throttle valve must not project beyond the shaft shoulder on any side. Axial clearance of the shaft between the bushes 0.4 to 0.7 mm.



2 Set the length of the engine brake cylinder. Set length (A) with the cylinder at rest until an angle of 90° ± 3° is obtained between the throttle valve and flange.

Note: There must be a distance of 5 mm between the engine brake lever and the retaining plate when the engine brake is at rest and when operated. If this distance is not obtained, the lever must be correspondingly displaced on the shaft.



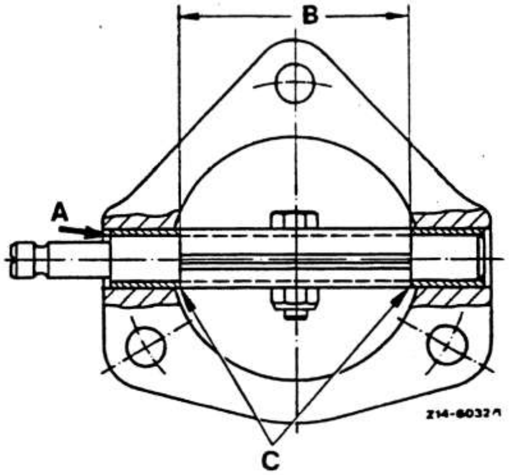
II Turbocharged engine

1 A Shaft shoulder and upper edge of bush on one level when pressing in.

Press in the bush until the lower shoulder of the shaft comes in contact with the second bush.

B Permissible deviation in center alignment from distance B to inside diameter of the manifold 0.2 mm.

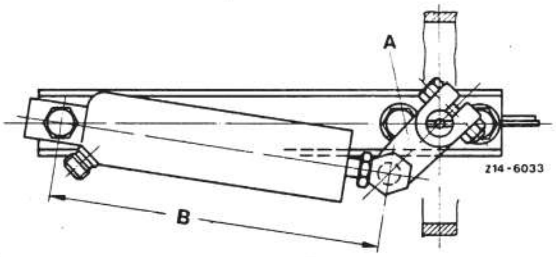
C The built-in throttle valve must not project beyond the shaft shoulder on any side. Axial clearance of the shaft between the bushes 0.4 to 0.7 mm.



2 Set length of motor brake cylinder.

2.1 Mount the engine brake lever (A) on the spline of the engine brake shaft such that the limit stop rests on the bracket of the engine brake cylinder when the throttle valve is completely open.

2.2 Detach engine brake cylinder. Set the length of the engine brake cylinder such that the hexagon pin can be easily mounted free of stress. Screw hexagon pin on to the motor brake cylinder by a further three turns.
(Preload).



15 – 5230 Removal and Installation of Alternator

Tightening torques	Nm
Alternator to bracket	50
Clamping piece to alternator	35

Special tools

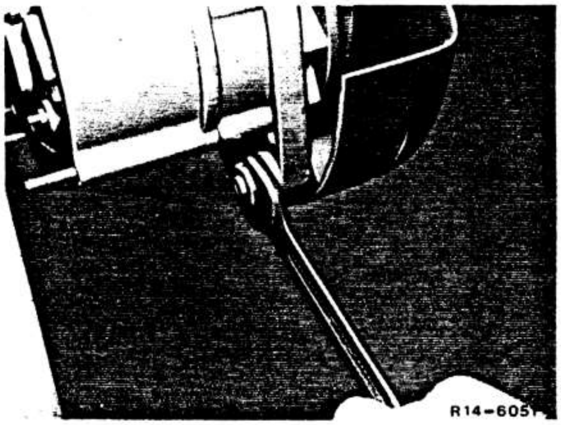
001 589 69 21 00

Removal

1 Disconnect battery cable.

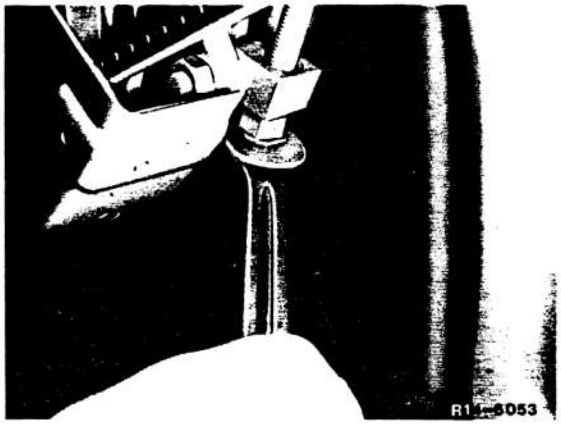
2 Disconnect electrical connections at the alternator.

3 Release clamping piece for the tensioning screw.



4 Loosen lock nut of the tensioning screw and relief tension of V-belt.

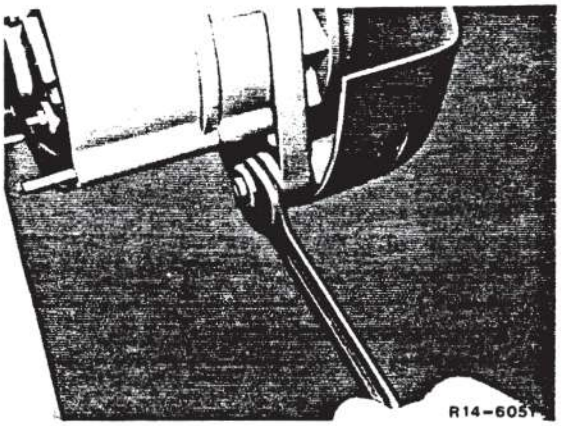
5 Unscrew alternator and remove.



Installation

1 Fit alternator in the bracket and tighten to 50 Nm.

2 Mount clamping piece of the tensioning screw on the alternator.



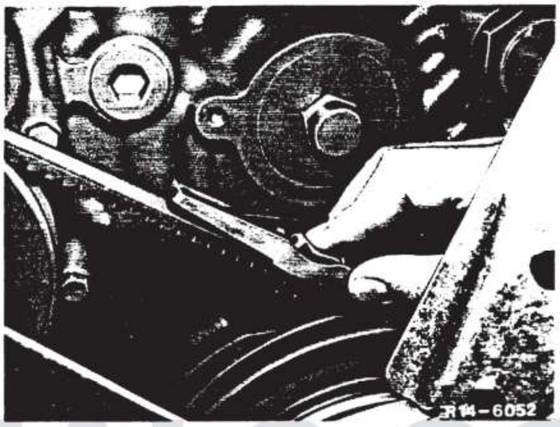
3 Fit V-belt and tension. Check V-belt tension with special tool.

4 Tighten clamping piece to 80 Nm and lock tensioning screw.

5 Attach electrical connections.

6 Connect battery cable.

Measuring device 001 589 69 21 00



15 – 7100 Removal and Installation of Starter

Tightening torques	Nm
Starter to crankcase	80

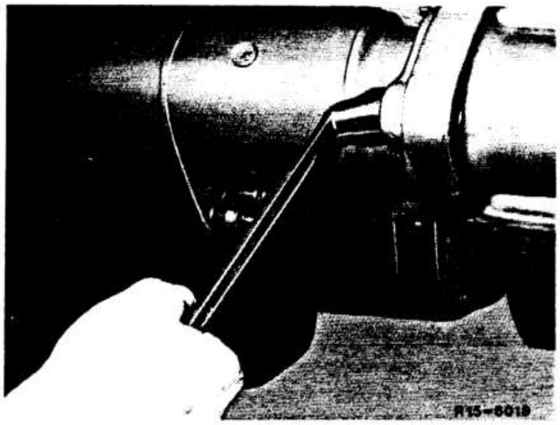
Removal

1 Disconnect battery cable.

2 Release electrical connections at starter.

3 Unscrew securing nuts.

4 Remove starter from below.



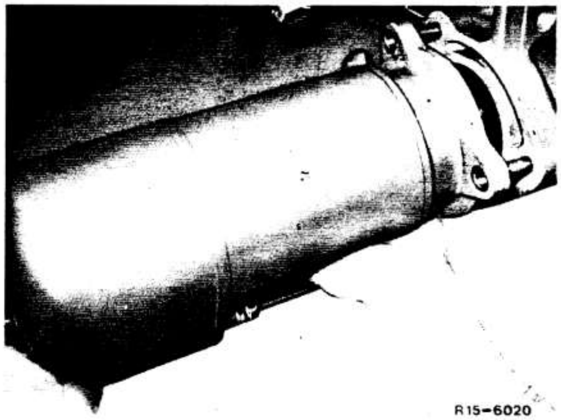
Installation.

1 Fit starter in stud bolts from below.

2 Tighten securing nuts to 80 Nm.

3 Attach electrical connections at the starter.

4 Connect battery cable.



R15-6020

18 – 010 Measuring Oil Consumption

The oil consumption of an engine can **only** be determined accurately in an **oil consumption test drive together with fuel consumption test.** Checking oil consumption with an oil dipstick is not accurate enough.

High oil consumption during the running-in period of an engine (up to about 20,000 km) is normal. During this time **no** oil consumption test drive should be made.

Since oil consumption depends to a great extent on the driving habits, i.e. load and speed of engine, **for normal vehicle operations** a test stretch of **at least 200 km** should be driven. The test drive should be made by the customer or driver.

The fuel consumption must also be measured during the oil test drive, since the different operating conditions (hill-climbing, city traffic, dumping operations, trailer hauling, etc.) can only be considered by a comparison between fuel consumption and oil consumption.

Before starting the oil consumption test drive, check engine for **any leaks which could be causing a loss of oil (e.g. on oil filter, on oil cooler, on cylinder head covers, etc.).**

Procedures for Measuring Oil Consumption:

1. Keep a clean container ready and weigh an empty container.

2. Run engine warm; coolant temperature should be 60 to 100° C.

3. Park vehicle on level ground and mark position, so that vehicle can be parked in same position after test drive.

4. Move throttle button to stop position. Check regulating lever on injection pump to make sure it is actually at Stop.

5. Unscrew oil pan plug and drain operating temperature oil into previously-mentioned clean container for 20 minutes. Start engine 10 seconds after 15 minutes of draining time, while operating engine retarder.

6. Fill fuel tank to 2 cm below edge of filler neck and mark or note exact height to fuel level.

7. Install and tighten oil pan plug again.

8. Weigh container with drained oil on a scale with gram graduations and correct the oil volume to the specified weight according to the appropriate filling capacity (weight of oil + weight of oil container).

9. Fill weighed oil volume into engine carefully so that no oil is spilled. The container, which will be needed again after the test drive, must not be used or cleaned during the test drive, since this would cause an error in weight.

10. Drive vehicle at least 200 km under previously mentioned conditions (possibly a normal vehicle operation of one day).

11. Park vehicle on marked position immediately after test drive.

12. Place container used earlier underneath vehicle and drain oil. Draining time again 20 minutes. Start engine for 10 seconds after 15 minutes of draining, while operating engine retarder (refer to point 4!) Then install and tighten plug.

13. Weigh container with oil again and determine oil consumption. It is the difference of the weights determined before and after the test drive.

The oil consumption (^{b}oil) is normally given in liters and is calculated from the difference in weight, the specific weight of the consumed oil and the travelled distance, according to the formula printed on the back of this test sheet.

14. Fill fuel tank to height before the consumption test drive an **determine the fuel volume consumed** during the test drive.

The fuel consumption (B fuel) is normally given in liters per 100 km. The conversion to 100 km is made according to a formula on the back of this test sheet.

15. The ratio between oil consumption and fuel consumption in % can be calculated with the given formula.

An oil consumption of 1% of the fuel consumption gives no reason for complaint.

Niederlassung/Vertretung Branch/Agency	Kunde Customer
	Messung ausgeführt: Datum/Name Measurement carried out: Date/Name

Typ Type	Fahrgestell-Nr. Chassis No.	Erstzulassung Original Registration
Rep.-Auftrag Nr. Repair order No.	Motor-Nr. Engine-No.	Tachometerstand: km/Meilen Speedometer reading: km/miles

Achtung! Vor der Meßfahrt Unterlagen des Kunden über Ölverbrauch genau prüfen.
Important: Check customer's documentation on oil consumption carefully prior to test drive

Einsatz des Fahrzeuges: (z.B. Fernverkehr, Kipperbetrieb, Anhängerbetrieb usw.)
Application of vehicle: (e.g. Long-distance driving, tipper operation, trailer operation, etc.)

Gesamtgewicht – Motorwagen Gross weight – Truck	t	Außentemperatur Ambient temperature	°C
Gesamtgewicht – Anhänger/Auflieger Gross weight – Trailer/Semi-trailer	t	Öldruck im Leerlauf (bei betriebswarmen Motor) Oil pressure, idling (with engine hot)	bar
Ölsorte Oil brand		Kühlmitteltemperatur Cooling water temperature	°C

Gewicht des leeren Meßgefäßes Weight of empty measuring receptacle	g	km-Stand nach der Meßfahrt Mileage (km reading) after test drive	km
Gewicht des Meßgefäßes mit Öl Weight of measuring receptable with oil		km-Stand vor der Meßfahrt Mileage (km reading) prior to test drive	km
vor der Meßfahrt prior to test drive	g	Laufstrecke Distance covered	km
nach der Meßfahrt after test drive	g	nachgefüllte Kraftstoffmenge nach der Meßfahrt Amount of fuel added after test drive	l
Gewicht des verbrauchten Öls Weight of oil consumed	g		

Ölverbrauch
Oil consumption

$$b_{öl} = \frac{\text{Gewicht des verbrauchten Öls (g) / Weight of Oil consumed grams)}}{b_{oil} \quad 0{,}85^{1} \text{ x } \text{Laufstrecke (km) / Distance covered (km)}} = \frac{\qquad}{0{,}85 \text{ x } \qquad} = \text{l/1000 km / ltrs/1000 km}$$

[1] Spez. Gewicht des Öls = 0.85 g/cm³
Specific gravity of the Oil

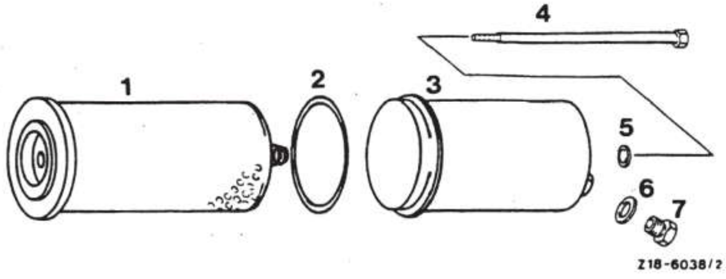
Kraftstoffverbrauch während der Meßfahrt (Vor und nach der Meßfahrt bis 2 cm von der Oberkante Einfüllstutzen auffüllen)
Fuel consumption during test drive (prior to and after test drive refill up to 2 cm from upper edge of filler neck)

$$\text{B-Kraftstoff / B/Fuel} = 100 \text{ x } \frac{\text{Kraftstoffverbrauch in l / Fuel consumption, ltrs}}{\text{Laufstrecke in km / Distance covered, km}} = 100 \text{ x } \frac{\text{l / ltrs}}{\text{km}} \; \text{l/100 km} = \text{ltrs/1000 km}$$

Ölverbrauch in % zum Kraftstoffverbrauch
Oil consumption as a percentage of fuel consumption

$$\% = 10 \text{ x } \frac{\text{b = Ölverbrauch l/1000 / b = Oil consumption ltrs./100ltrs./1000 km}}{\text{B = Kraftstoffverbrauch l/100 / B = Fuel consumption ltrs./100}} = 10 \text{ x } \frac{\text{l/1000 km / ltrs/1000 km}}{\text{l/100 km / ltrs/100 km}} = \%$$

18 – 3460 Removal and Installation of Oil Filter Element



1	Filter element	renew
2	Sealing ring	renew
3	Oil filter bowl	
4	Bolt	50 Nm
5	Sealing ring	renew
6	Sealing ring	renew
7	Screw plug	50 Nm

Removal

1 Unscrew oil drain plug at the oil filter bowl and drain oil.

2 Unscrew oil filter bowl and remove with filter element.

3 Lift out filter element from the filter bowl and remove O-ring.

Installation

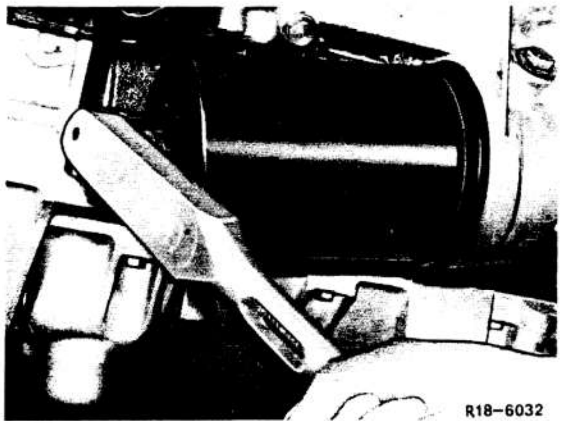
1 Place new O-ring on the sealing surface of the oil filter bowl.

2 Fit new filter element – the spring must face towards the bottom of the oil filter bowl – in the oil filter bowl. Oil rubber seal of the filter element.

3 Place oil filter bowl with filter element on the oil filter bracket. The oil drain plug must face downwards. Screw in center bolt and tighten to 50 Nm.

4 Tighten oil drain plug to 50 Nm.

Note: Before starting, the engine must be cranked with the starter until pressure is indicated by the oil pressure gauge. When cranking, the engine brake must be engaged or the pull stop set to "stop" otherwise the engine will start. **The starter must not be operated in excess of 20 seconds at a time, otherwise it will overheat and become damaged.** If oil pressure is still not indicated, interrupt the start procedure and repeat after approx. 1 minute at a time.



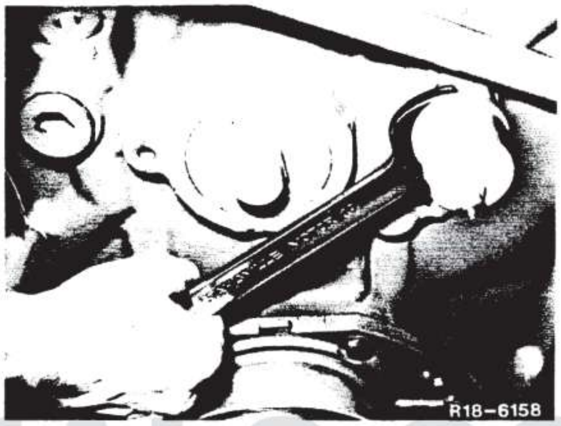
5 After starting, check the engine and the oil filter for leaks.

18 – 4130 Renewing Oil Pressue Pickup

Removal

1 Unscrew cable at oil pressure pickup.

2 Remove oil pressure pickup.



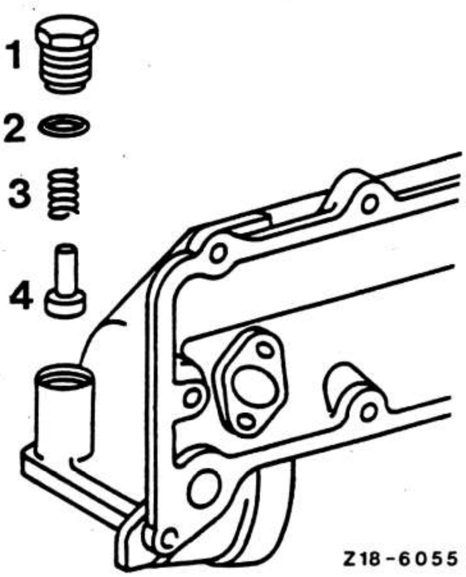
R18–6158

Installation

1 Screw in oil pressure pickup with new sealing ring and connect electrical wire.

R18–6159

18 – 5010 Removal and Installation of Oil Filter Bypass Valve



1	Screw plug	60 Nm
2	Sealing ring	renew
3	Spring	
4	Valve	

Data

Spring for bypass valve	Inside ∅	Spring wire thickness	No-load length	Length under preload (valve open)		Length under final load		Opening pressure of oil bypass valve
				mm	N	mm	N	
	13.5	2.25	53.6	42.1	64.4	31	139.5	$2^{+0.6}_{-0.2}$

Removal

1 Unscrew drain plug from the oil filter bowl, drain oil.

2 Unscrew screw plug for bypass valve, remove together with valve piston and valve spring.

3 Check valve spring on a suitable spring test balance.

R18-6157

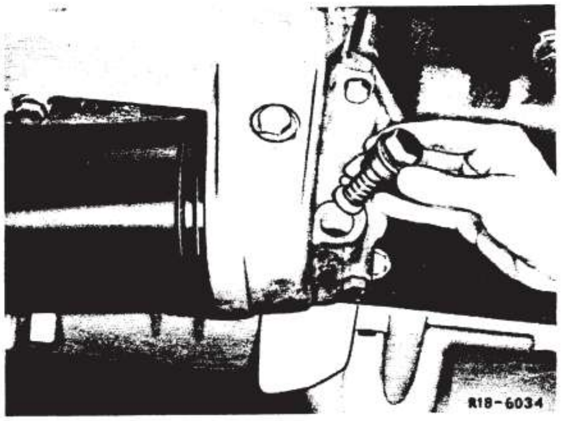
Installation

1 Fit valve piston, spring and screw plug in the oil filter bowl.

Note: Use new sealing ring.

2 Tighten screw plug to 60 Nm.

3 Tighten oil drain plug in oil filter bowl to 50 Nm and fill with oil.



18 – 5040 Removal and Installation of Pressure Control Valve

Data	
Pressure control valve opens at	6.5 ± 0.7 bar

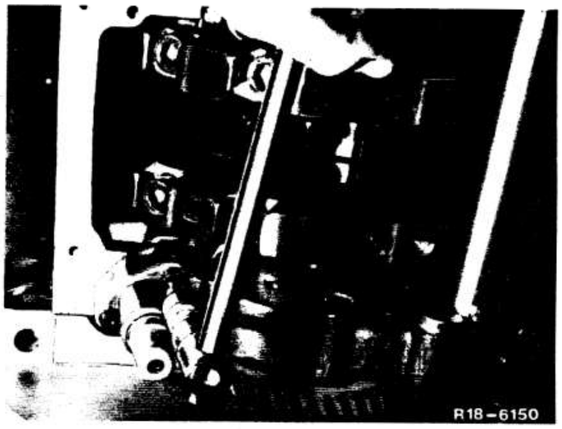
Tightening torques	Nm
Oil pan to crankcase	30
Pressure control valve to crankcase	35

Removal

1 Drain engine oil.

2 Remove oil pan.

3 Unscrew pressure control valve at the crankcase.

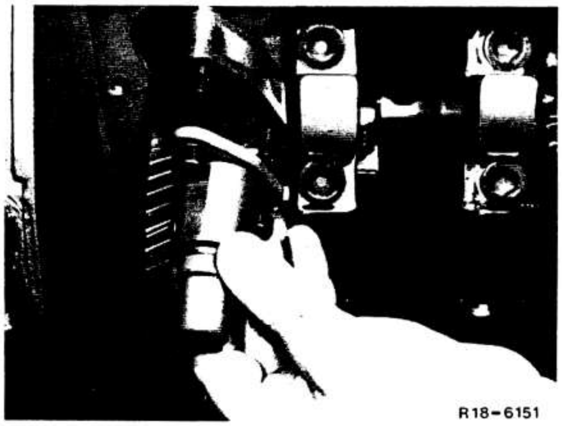


Installation

1 Fit pressure control valve on crankcase and tighten to 35 Nm.

2 Mount oil pan with new gasket and tighten to 30 Nm.

3 Fill with engine oil.



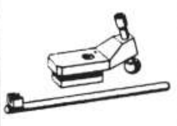
18 – 5450 Removal and Installation of Oil Spray Nozzle

Crankshaft removed

Data	
Inside diameter of oil spray nozzle	2 mm

Tightening torques	Nm
Oil spray nozzle to crankcase	47

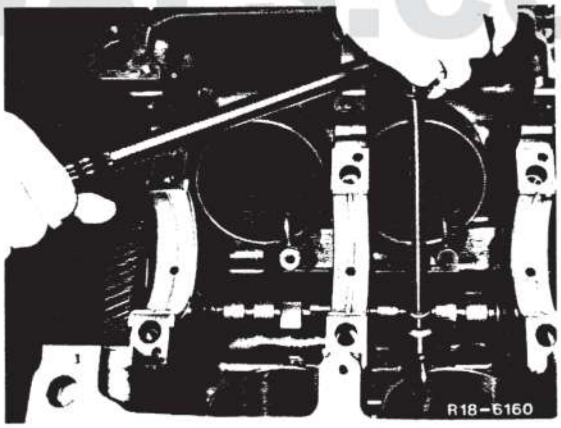
Special tools



403 589 01 23 00

Removal

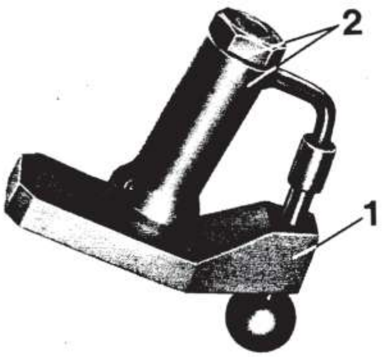
1 Remove oil spray nozzle from the crankcase.



Installation

1 Check spraying direction of the oil spray nozzle (2) with special tool.

Testing device (1) 403 589 01 23 00

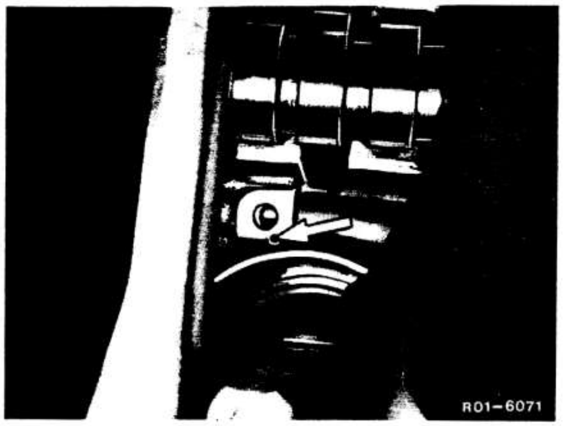


R 18-6053

2 Fit the oil spray nozzle in the crankcase such that the fitted pin engages in the hole in the crankcase (arrow) and tighten to 47 Nm.

Note: An oil guard is installed in combination with the oil spray nozzle at cylinder No. 3 of turbocharged engines.

Arrow = Hole for fitted pin



18 – 6020 Removal and Installation of Oil Pump

Tightening torques	Nm
Oil drain plug to oil pan	80
Oil pan to crankcase	30
Oil pump to crankcase	35

Removal

1 Drain engine oil.

2 Unscrew oil pan.

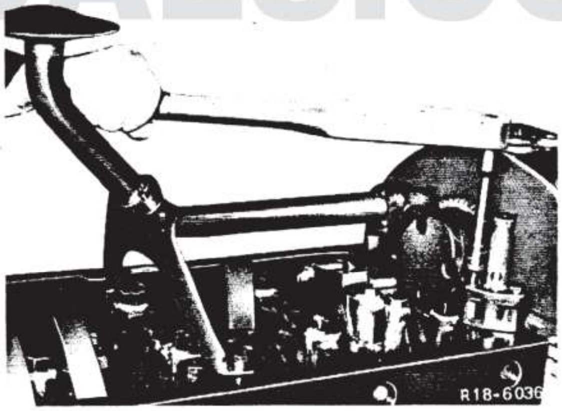
3 Unscrew oil pump at crankcase and remove with oil intake tube.

Installation

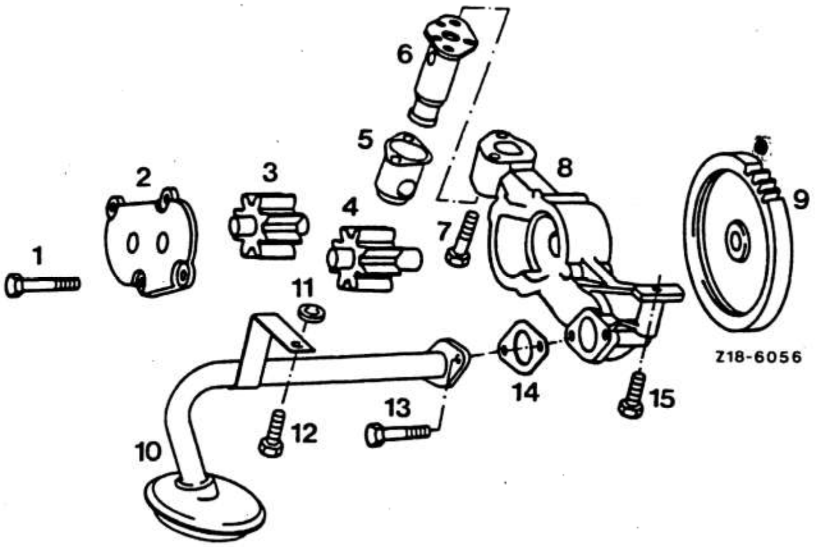
1 Fit oil pump together with oil intake tube to crankcase and tighten to 35 Nm.

2 Bolt oil pan to crankcase and tighten to 30 Nm.

3 Screw in oil drain plug to 80 Nm and fill with engine oil.



18 – 6060 Disassembly and Assembly of Oil Pump


1
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Z18-6056

1	Bolt	25 Nm
2	Cover	
3	Gear, driven	443 LA, 2 gears
4	Gear, driving	
5	Protective sleeve	
6	Pressure control valve	
7	Bolt	35 Nm
8	Oil pump housing	
9	Driver gear	
10	Intake tube	443 LA, 2 tubes
11	Washer	
12	Bolt	35 Nm
13	Bolt	35 Nm
14	Gasket	renew
15	Bolt	35 Nm

Data

Engine	441	441 LA 442	442 A 442 LA 443	443 LA 444 A[1] 444 LA[1]
Bore in oil pump housing	18.018/18.000	18.018/18.000	22.021/22.000	22.021/22.000
Diameter of drive shaft	17.994/17.993	17.994/17.993	21.994/21.993	21.994/21.993
Inside diameter of oil pump drive gear	17.885/17.870	17.885/17.870	21.885/21.870	21.885/21.870
Housing height for gear wheels	28.033/28.000	34.039/34.000	43.039/43.000	28.033/28.000
Height of oil pump gear wheels	27.960/27.927	33.950/33.911	42.950/42.911	27.960/27.927
Radial clearance of oil pump gear wheels between housing and gear wheel	0.030/0.122	0.030/0.122	0.030/0.122	0.030/0.122
Axial clearance of oil pump gear wheels between housing cover and gear wheel	0.040/0.106	0.050/0.128	0.050/0.128	0.040/0.106
Backlash of oil pump gear wheels	0.312/0.476	0.312/0.476	0.312/0.476	0.312/0.476
Number of driven oil pump gear wheels	1	1	1	2
Pressure control valve opens at in bar overpressure	6.5 ± 0.7	6.5 ± 0.7	6.5 ± 0.7	6.5 ± 0.7
Oil pump check at engine speed 600 rpm: Minimum flow rate in l/min measured with SAE 10 oil, oil temperature 50° C, oil backpressure 4 bar.	25	29.4	37	51

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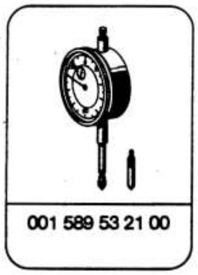
[1] Industrial engine

Special tools



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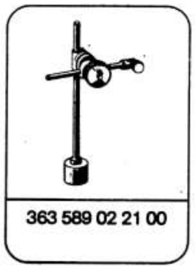
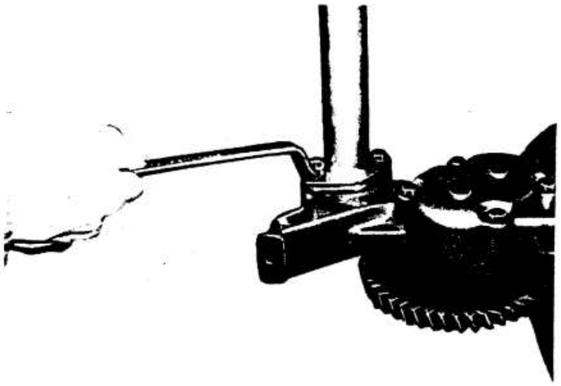


363 589 02 21 00

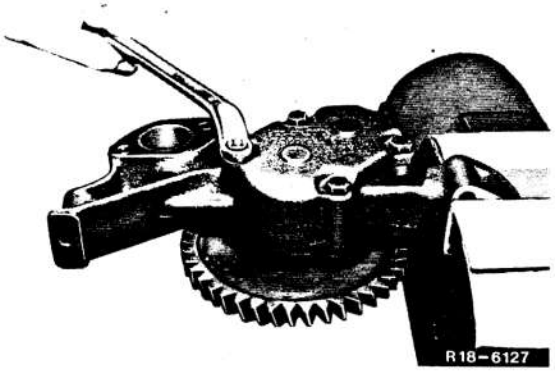
Disassembling oil pump

1 Unscrew intake tube (443 LA, 2 tubes).

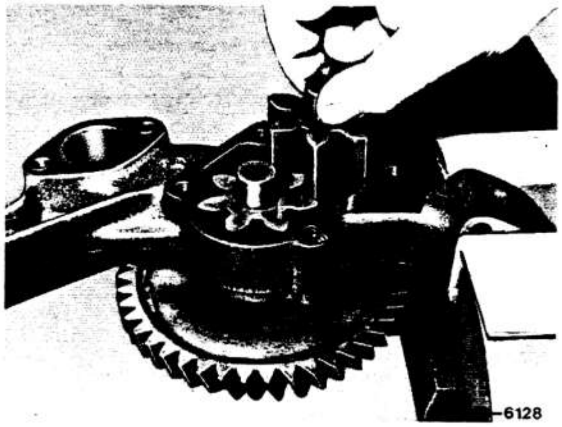


R18–6126

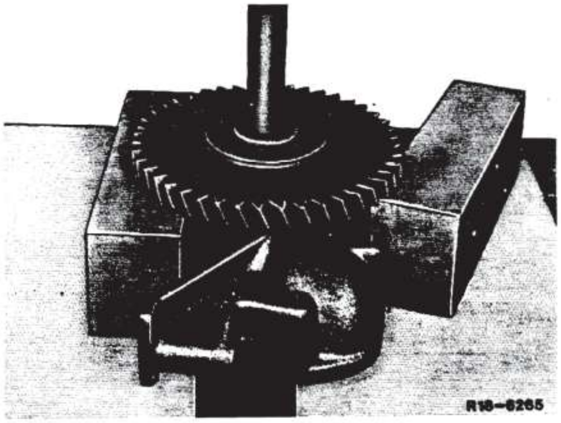
2 Unscrew housing cover.



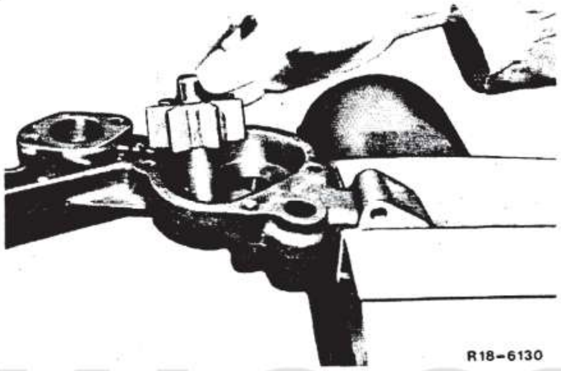
3 Remove driven gear wheel (443 LA, 2 gears) together with shaft from the housing.



4 Press out shaft with driving gear wheel from the drive gear.

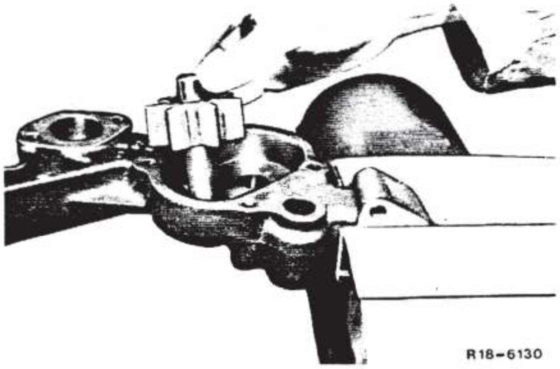


5 Remove driving gear wheel with shaft from the housing.



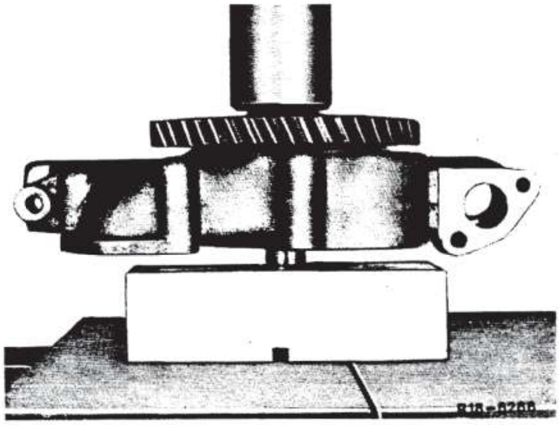
Assembling oil pump

1 Fit driving gear wheel with shaft in the housing.

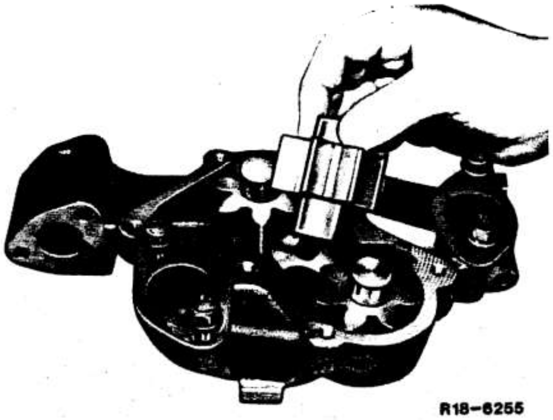


2 Heat drive gear on a hotplate and fit on the drive shaft.

Note: Mount drive gear flush with the chamfer of the drive shaft.

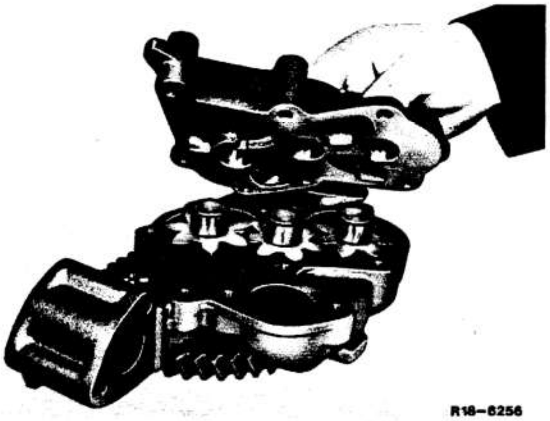


3 Fit driven gear wheel (443 LA, 2 gears) together with shaft in the oil pump housing.



R18-6255

4 Place housing cover in position and tighten securing bolts to 25 Nm.



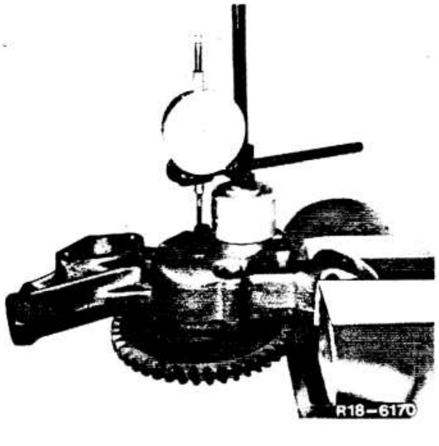
R18-6256

5 Mount dial gauge holder with dial gauge on the oil pump.

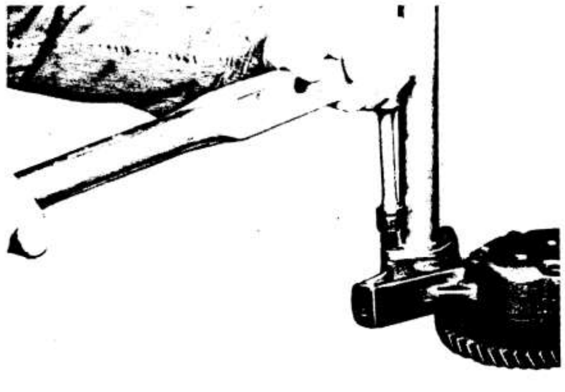
6 Set plunger of dial gauge under preload on the oil pump shaft.

7 Press down oil pump shaft and set dial gauge to "0".

8 Press oil pump shaft against the dial gauge and read off axial clearance.

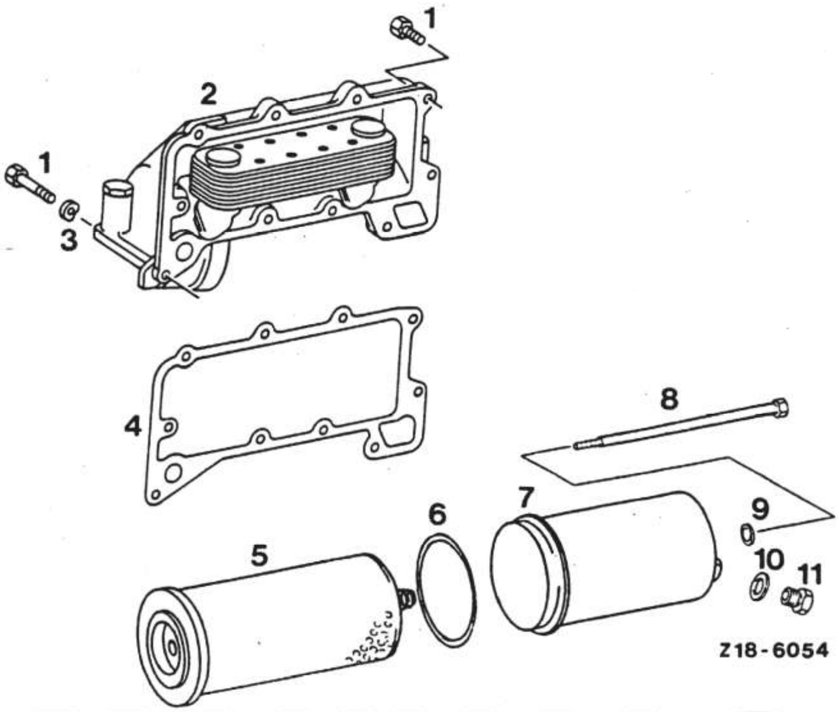


9 Fit oil intake tube (443 LA, 2 tubes) with new gasket and tighten to 25 Nm.



R18-6132

18 – 6820 Removal and Installation of Oil Cooler

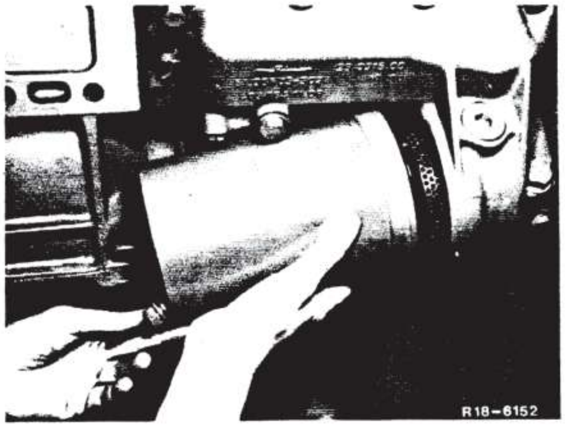


1	Bolt	70 Nm
2	Oil cooler, complete	
3	Spring washer	
4	Gasket	renew
5	Filter element	renew
6	Sealing ring	renew
7	Filter housing	
8	Bolt	50 Nm
9	Sealing ring	renew
10	Sealing ring	renew
11	Screw plug	50 Nm

Removal

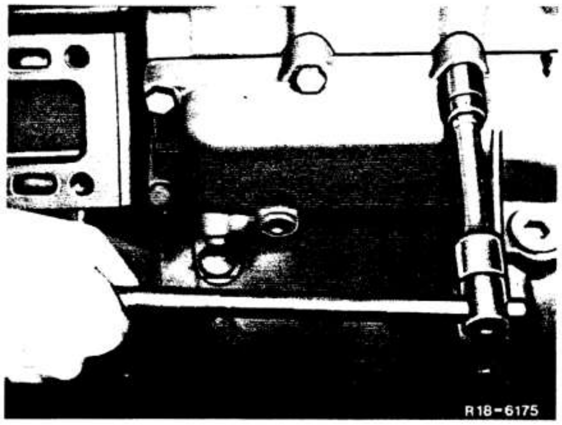
1 Unscrew oil drain plug at oil filter bowl and drain oil.

2 Unscrew oil filter bowl and remove together with filter element.



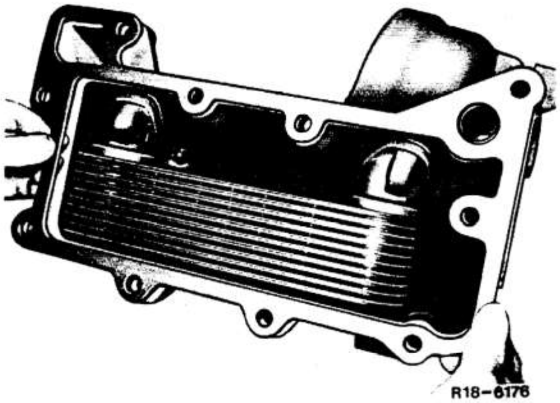
3 Release coolant drain plug at the oil cooler and drain coolant.

4 Unscrew oil cooler at the crankcase and remove.


R18-6175

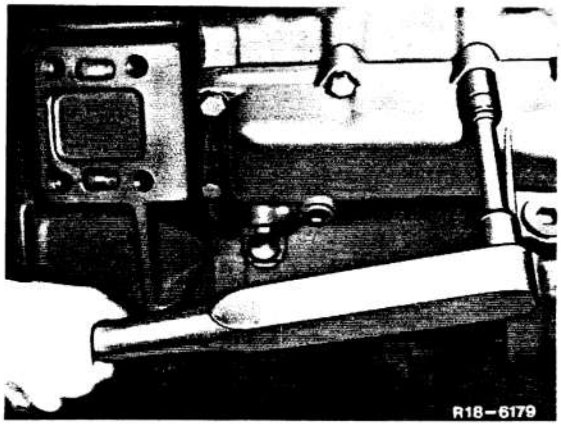
Installation

1 Fit new gasket on the oil cooler.

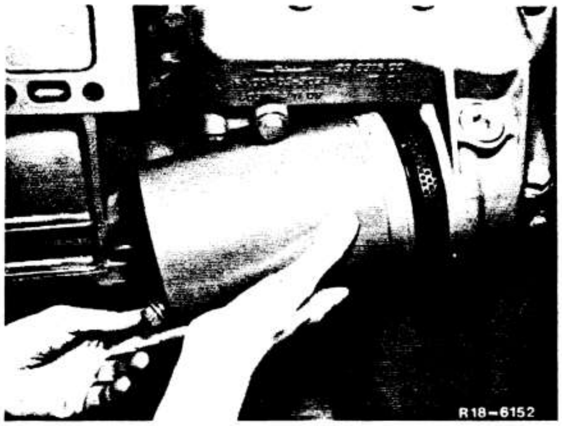

R18-6176

2 Place oil cooler in position on the crankcase and tighten to 70 Nm.

3 Screw in coolant drain plug in the oil cooler housing and tighten to 50 Nm.

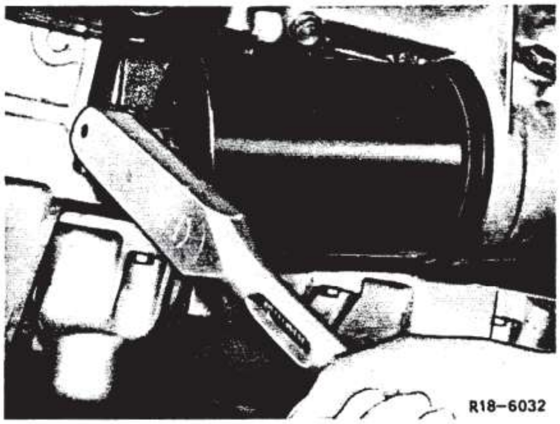

R18-6179

4 Fit oil filter bowl with filter element on the oil filter bracket. The oil drain plug must face downwards.

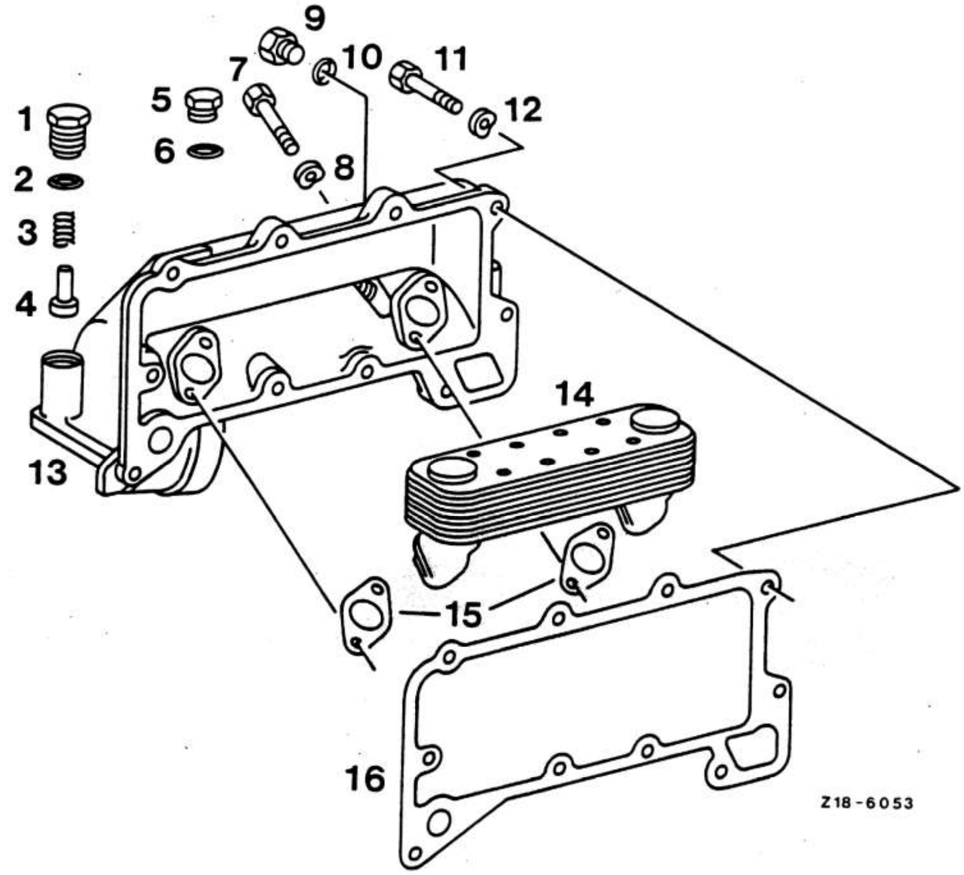

R18-6152

5 Tighten oil filter bowl to 50 Nm.

6 Tighten oil drain plug to 50 Nm.



18 – 6900 Disassembly and Assembly of Oil Cooler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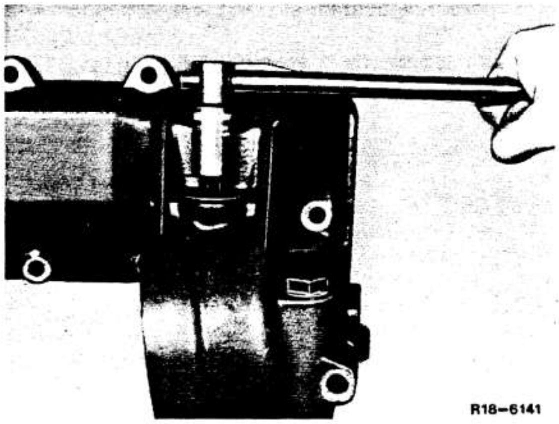
Z18-6053

1	Screw plug	60 Nm
2	Sealing ring	renew
3	Spring	
4	Valve	
5	Screw plug	80 Nm
6	Sealing ring	renew
7	Bolt	50 Nm
8	Spring washer	
9	Bolt	50 Nm
10	Sealing ring	renew
11	Bolt	70 Nm
12	Spring washer	
13	Cover	
14	Oil cooler	
15	Gasket	renew
16	Gasket	renew

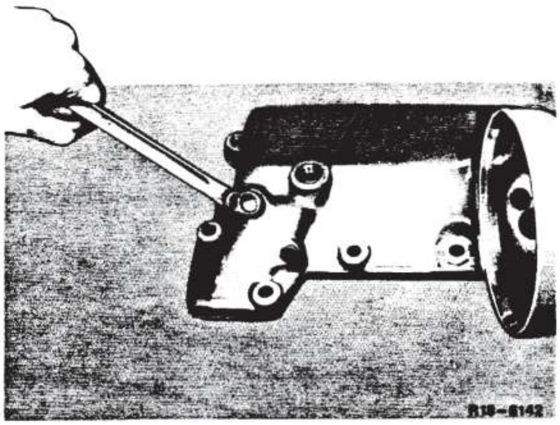
Disassembly

1 Unscrew drain plug for oil filling.



2 Loosen bolts holding the oil cooler and remove oil cooler.

3 Remove oil filter bypass valve.

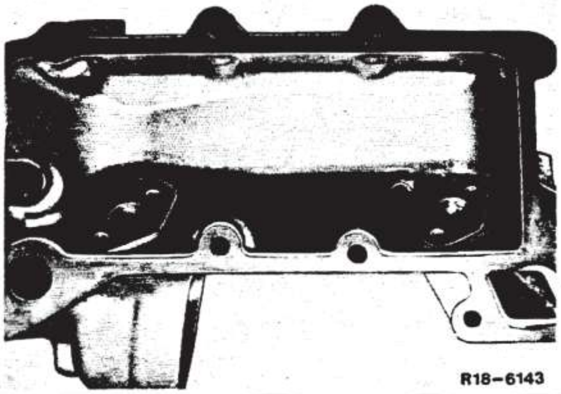


R18-6142

Assembly

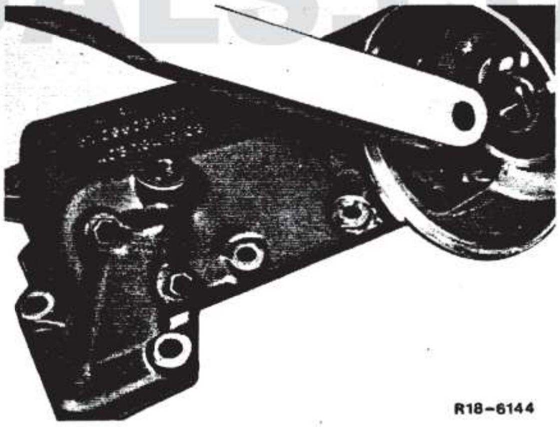
1 Fit gaskets for oil cooler.

Note: Mount the graphite side of the gaskets facing towards the oil cooler.



R18-6143

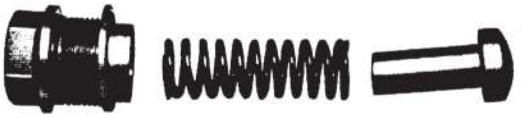
2 Install oil cooler and tighten to 25 Nm.



R18-6144

3 Fit screw plug for oil filling and tighten to 50 Nm.

4 Fit oil filter bypass valve and tighten to 60 Nm.



R18-6157

20 – 1030 Degreasing and Decalcifying Cooling System

Degreasing

1 Completely drain coolant.

2 Remove thermostat element and set heater lever to "warm".

3 Fill the cooling system with a 5% solution of water and a mildly alkaline cleaner, such as P3-Croni (supplier: Henkel) or Grisiron 7220 (supplier: Farbwerke Hoechst) (50 g P3-Croni/1 liter water).

4 At medium engine speed, run engine warm to a temperature of approx. 80° C and maintain this temperature for approx. 5 minutes. The radiator can be covered if necessary.

5 Switch off engine and allow cooling system to cool down to a temperature of approx. 50° C.

6 Completely drain solution.

7 Immediately after this, fill cooling system twice with fresh water, run warm (approx. 5 minutes) and drain.

Decalcifying, Derusting

Note: Prior to decalcifying, the cooling system must be thoroughly degreased even when there are no visible signs of oiling.

1 After flushing the cooling system during degreasing for a second time, fill the cooling system with a 10% (100 g/l) solution of water and citric acid, tartaric acid or oxalic acid (available from the chemical trade), whereby preferably citric acid should be used.

2 At medium engine speed, run engine warm to a temperature of approx. 80° C and maintain this temperature for approx. 10 minutes.

3 Switch off engine and allow to cool to approx. 50° C.

4 Completely drain decalcifying solution.

5 Flush cooling system at least three times with fresh water. For this purpose run the engine for 5 minutes during each flushing operation.

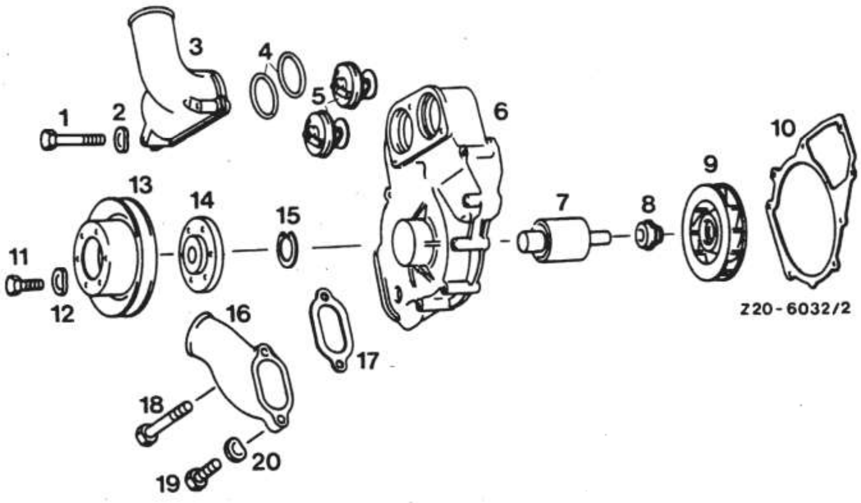
6 Install thermostat element with new sealing ring.

7 Fill cooling system with specified coolant.

Note: Commercially available products, consisting of the above mentioned acids, can also be used for decalcifying and derusting.

Due to the problems as regards drainage, chromic acids or products containing chrome should not be used.

20 – 1390 Disassembly and Assembly of Coolant Pump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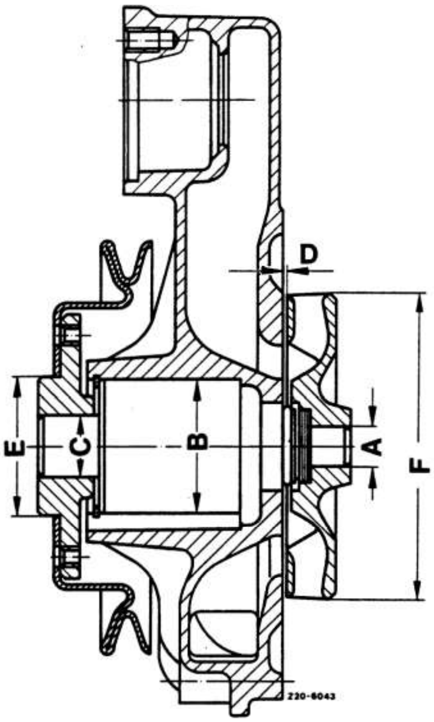
Z20-6032/2

1	Bolt	25 Nm
2	Washer	
3	Housing cover	
4	O-ring	renew
5	Thermostat	
6	Coolant pump housing	
7	Bearing	
8	Gasket	renew
9	Impeller	
10	Gasket	renew
11	Bolt	25 Nm
12	Washer	
13	Pulley	
14	Hub	
15	Retaining ring	
16	Inlet neck	
17	Gasket	renew
18	Bolt M 10	50 Nm
19	Bolt M 8	25 Nm
20	Washer	25 Nm

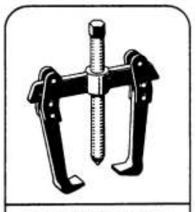
Data

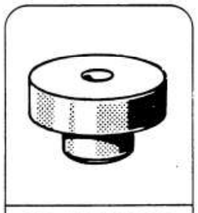
Dimension "A"	⌀ of shaft	15.045 15.045
	⌀ in impeller	15.018 15.000
Dimension "B"	⌀ coolant pump bearing	15.994 15.981
	⌀ in housing	54,970 54.940
Dimension "C"	⌀ of shaft	25.061 25.048
	⌀ in hub	25.021 25.000
Dimension "D"	Distance between impeller and housing	0.6–1.0
Dimension "E"	Outside diameter of hub	55.970 55.940
Dimension "F" Outside ⌀ of impeller	441, 442, 443 441 LA, 442 A, 442 LA	125
	443 LA	136
	442 A[1]/442 LA[1] 444 A[1]/444 LA[1]	

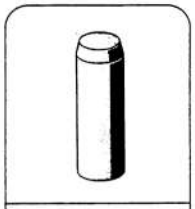
[1] Industrial engine



Special tools

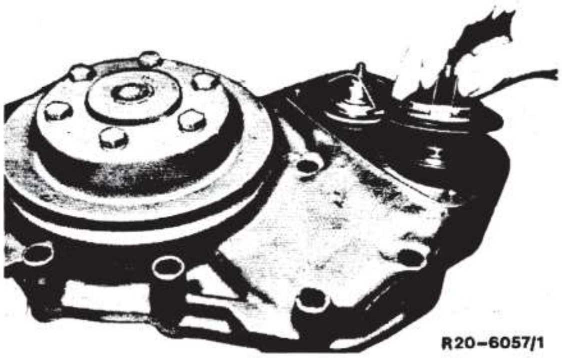

000 589 65 33 00


321 589 00 63 00


352 589 0815 00

Disassembly

1 Unscrew thermostat housing cover and remove thermostat.

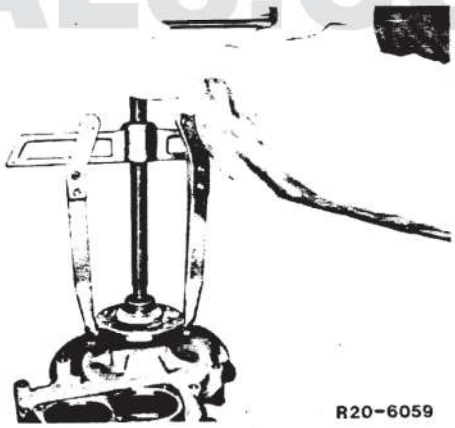

R20-6057/1

2 Unscrew pulley and remove.

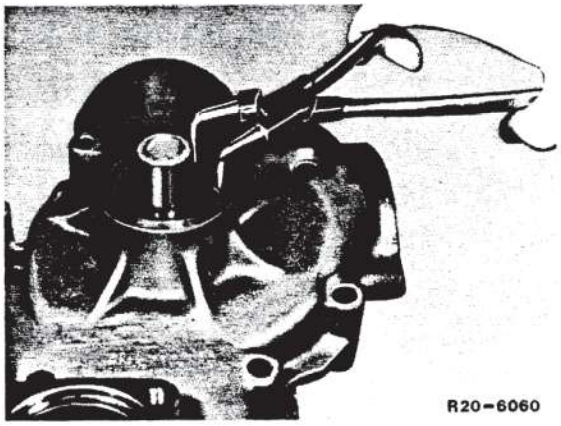
R20-6058

3 Remove flange for pulley with special tools.

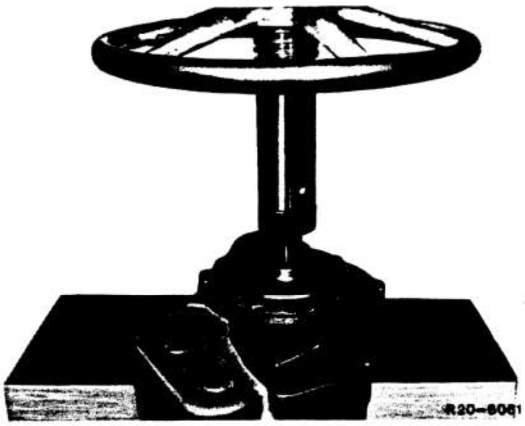
Puller	000 589 65 33 00
Thrust piece	321 589 00 63 00


R20-6059

4 Remove retaining ring.

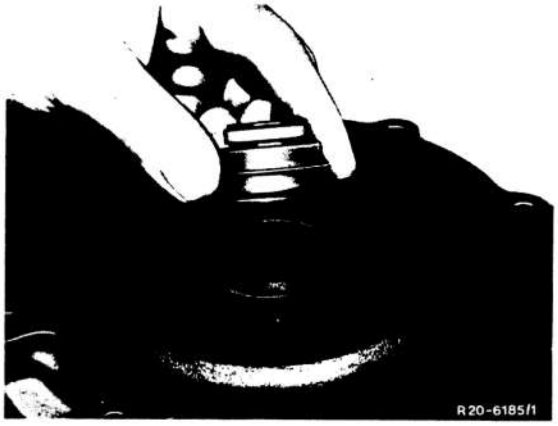

R20-6060

5 Press coolant pump bearing out from the impeller and the housing with a thrust piece.



R20–6061

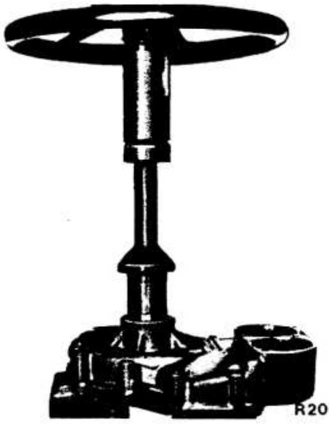
6 Remove cassette seal.



R20-6185/1

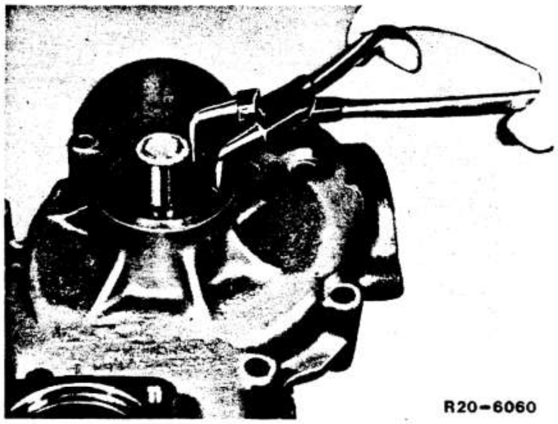
Assembly

1 Press coolant pump bearing into the housing.



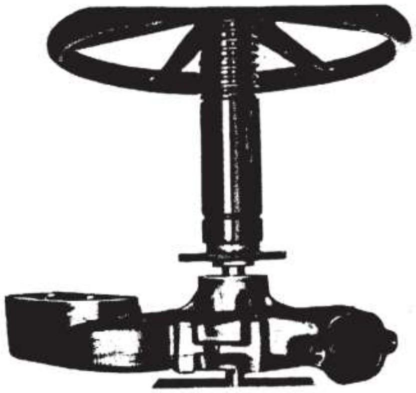
R20–6064

2 Fit retaining ring.

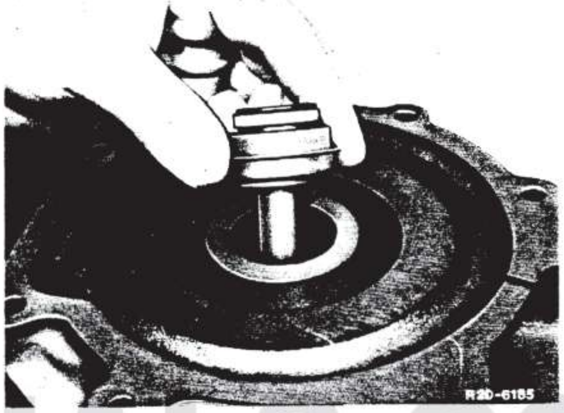


R20–6060

3 Press flange for pulley flush onto the coolant pump bearing.

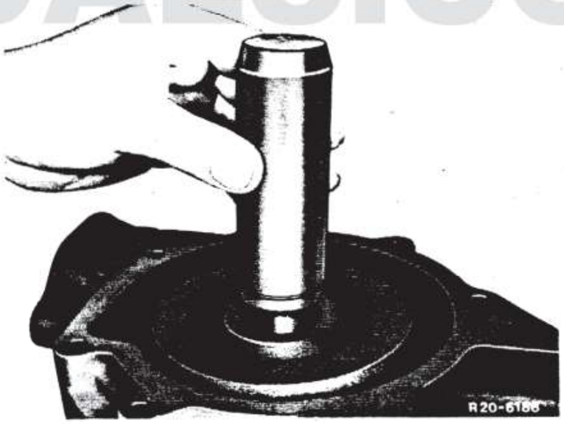

R20-6065

4 Fit cassette seal over the shaft.

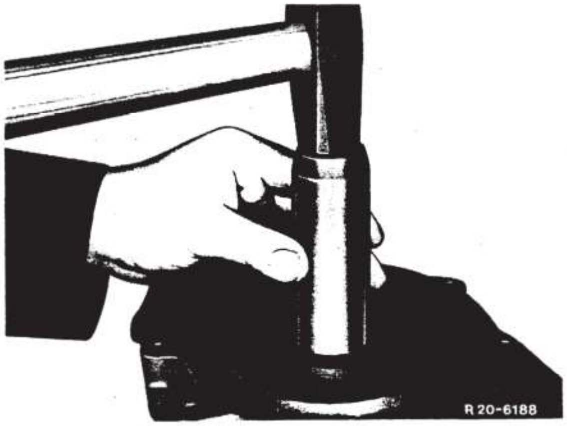

R20-6185

5 Press in cassette seal with drift to the coolant pump housing.

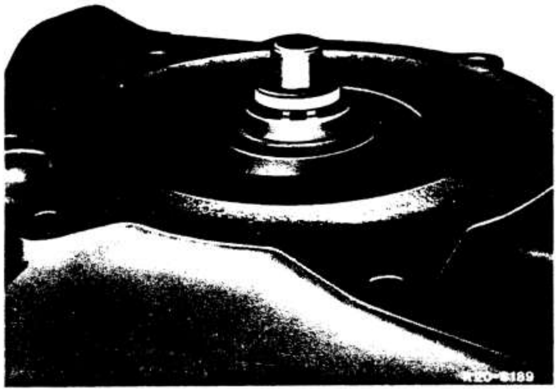
Drift 352 589 08 15 00


R20-6186

6 Install cassette seal with drift.

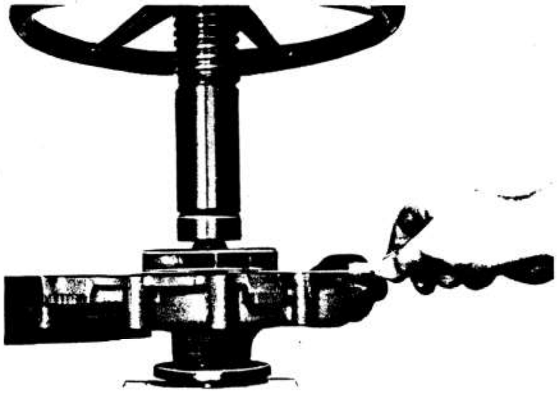

R20-6188

Note: Check that cassette seal is correctly fitted.



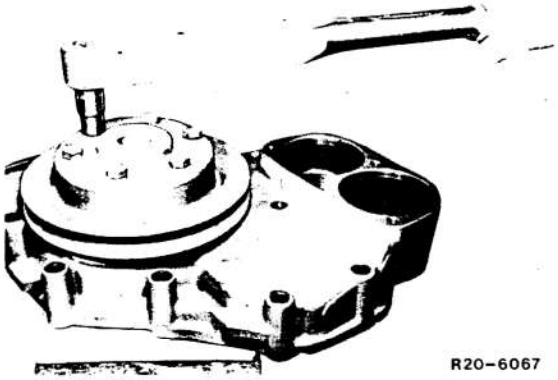
7 Place coolant pump impeller over the shaft.

8 Press coolant pump impeller onto the coolant pump bearing so that a gap size of 0.6–1 mm remains.



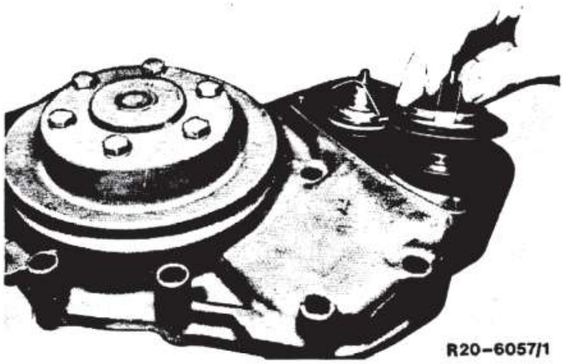
R20-6066

9 Mount pulley and tighten to 25 Nm.



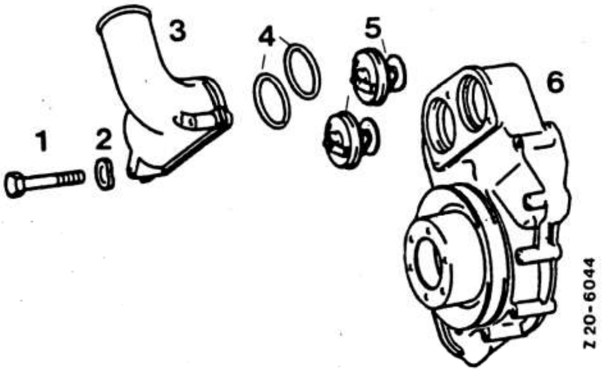
R20-6067

10 Fit thermostat with seals in the coolant pump and mount housing cover.



R20–6057/1

20 – 2470 Removal, Installation and Checking of Thermostat



1	Bolt	25 Nm
2	Washer	
3	Housing cover	
4	O-ring	renew
5	Thermostat	
6	Coolant pump	

Data

Thermostat		Standard version	Tropics version	Industrial engines
Start of opening at ° C		83 ± 2	71 ± 2	79 ± 2
Main valve	Travel in mm	8	8	8
	Completely open at ° C	95	85	87
Bypass valve	Travel in mm	6,2–7,5	6,2–7,5	6,2–7,5
	Closed at ° C	92	82	84
Amount of leakage water of main valve at 1 bar and 20° C at l/min		0.67–1.17	0.67–1.17	0.67–1.17
Max. flow rate with main valve open and at a pressure of 1 bar in l/min		333	333	333